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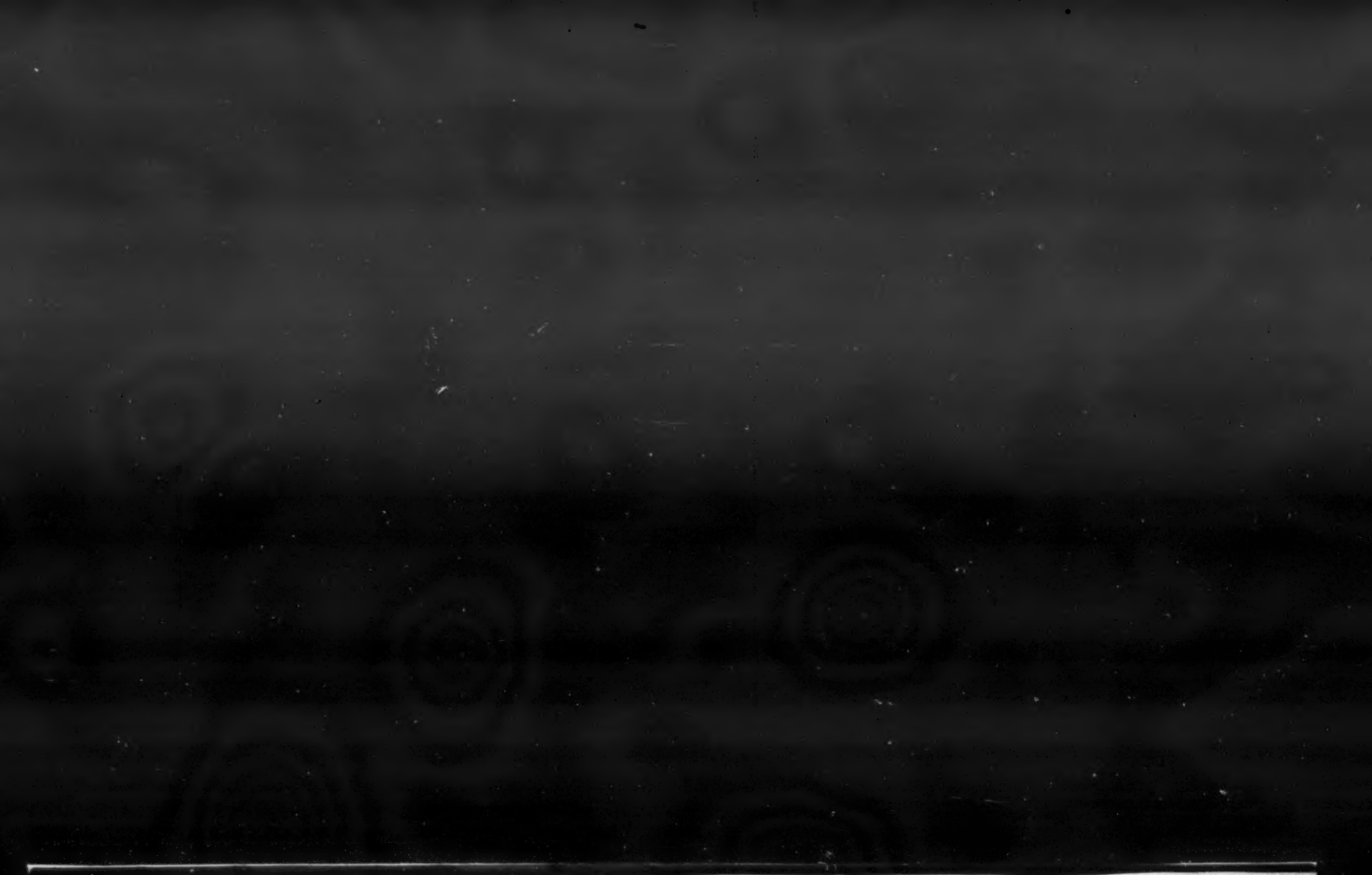


THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XLVII.—*The Temperature Variation of the Thermal Conductivities of Marble and Slate;* by B. O. PEIRCE and R. W. WILLSON.

IN the course of an investigation on the absolute thermal conductivities of certain poor conductors, which has occupied us for the last two years, we have obtained some preliminary measures of the temperature variation of conductivity, which we are permitted by the Rumford Committee of the American Academy of Arts and Sciences to present here in advance of the publication of the complete paper.

Our experiments were made by the so-called "Wall Method" upon square prisms. In one form of apparatus which we have used the prism to be tested is enclosed between two planed iron plates, one of which forms the top of a jacketed chamber through which steam may be passed for some hours at a time, while the other is the bottom of a vessel containing a little water and a large quantity of ice, with suitable stirrers and scrapers to insure the constant removal of the film of water immediately against the surface. These plates are fastened firmly together by bolts around their edges to insure close contact with the body under experiment. It is thus possible to keep the boundary planes at temperatures nearly a hundred centigrade degrees apart; the continuous observation of the interior temperatures renders it easy to see when the stationary state is reached and to insure that it is maintained.

The actual measurement of the interior temperatures is a matter of more difficulty. Inasmuch as the prism must be thin, it is necessary to determine with considerable accuracy the posi-

tion of the point at which the temperature is taken, and there can be no question, we think, that this compels the use of thermal junctions for that purpose. We did not attempt to employ fine platinum resistance coils, on account of difficulties which arise from the use of leads of considerable dimensions.

In the case of certain substances, such as sulphur or cement, which can be made to solidify about a system of stretched wires carefully spaced, it is possible to imbed thermopiles in fairly homogeneous prisms with the leads lying in what will be isothermal surfaces, so that there need be no fear of direct conduction of heat to or from the junctions, but such a process as this is manifestly inapplicable in the case of stone. After discussing the possibility of boring holes from the edges of a stone slab, we determined that it would be worth while to try the experiment of building up the prism out of separate slabs, clamped firmly together by means of the outside plates, with thermopiles fitting closely in fine grooves in the faces of the slabs, made with the help of a milling machine. It would not be easy, however, to make such grooves in glass plates, and we saw no better way of proceeding than to clamp the thermopiles between the plates. This, of course, raises some serious questions as to the difference between the indications of the thermal junctions and the true temperatures at the two surfaces with which the wire is in contact. It is obvious that the spaces between the slabs should be as small as possible and therefore that the thermopiles should be of fine wire. In advance of any experiment on the subject, it seemed that the communication of heat from radiation alone across a film of air, at most a small fraction of a millimeter in thickness, would be sufficient to prevent any great inequality of temperature, and that the thermopiles would give a close approximation to the mean of the temperatures at the two surfaces.

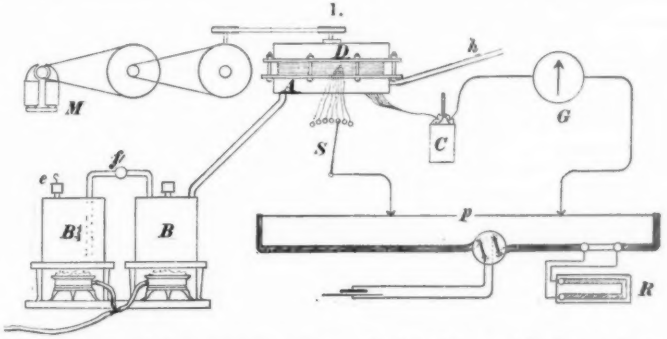
On these considerations we decided to make preliminary experiments in this manner, using marble as the experimental substance. How far the event has justified these considerations will appear later. The apparatus used in our first experiments was as follows:

Upon a heavy table was placed the hot chamber A [figure 1] connected with the copper boilers B, B′, for generating steam. The boiler B, which held about 40 liters, was constantly heated and was refilled when nearly empty without stopping the constant flow of steam, by filling B′, heating to the boiling point, suddenly closing the opening at *e* with a weight which acted as a safety valve, and opening the communication at *f*. The generation of steam in B′ served to drive the water over into B without causing a cessation of the flow of steam through the hot chamber, and the communication between the two boilers was then cut off. This process was necessary at least once in

each heating. The steam, after passing through a hot chamber A, was led to the outer air by a jacketed pipe, *h*, descending* from the bottom of A.

The planed upper surface of the chamber is about 70^{cm} square and inside the bolt holes of its flanges there is a clear space of 65^{cm} square. Directly upon this face was laid the first slab of marble about 60^{cm} square and 1^{cm} thick. The leads from two thermal junctions of platinoid-copper were then stretched across the middle of the slab so that the junctions were on the transverse middle line of the slab, about 1^{cm} from the vertical axis. The second slab placed upon these held them firmly in place, bearing on the slightly thickened junctions; upon the second slab were placed two more thermopiles, and the pile of slabs thus built up, to the number of seven, formed a prism about 60^{cm} square and 7^{cm} thick. Upon the upper slab was placed the planed lower surface of the square iron box D, which held the ice and water to cool the upper surface. The flanges of the upper and lower castings were then bolted firmly together and the slabs pressed as closely into contact as possible, the average thickness of the slabs being 1^{cm} and of the spaces 0·3^{mm}.

1.



A portion of the upper pan was isolated by soldering a brass cylinder 12·3^{cm} in inside diameter with its axis vertical in the centre of the pan. This served as a center for a horizontal six-armed stirrer actuated by the motor M and provided with stiff brushes, which swept over the bottom of the pan twice a minute, and which carried about 15 kilograms of ice in a wire basket reaching within 5^{mm} of the bottom. The cylinder, which was provided with its own stirrer inside and had an elaborate system of guards and jackets, which we do not need to describe here, served to isolate the heat coming out from a considerable surface at practically a uniform temperature near the axis of the prism. The amount of ice melted in the cylinder in a given

* In the diagram, *h* is represented as *ascending* and as inserted in the *side* of A

time gave the amount of heat conducted through the slab per second per unit of area.

The platinoid ends of the thermal junctions were soldered together and placed in an oil bath, C, immersed in melting ice. To them was soldered a copper wire leading to the (copper) wire of a potentiometer. The copper ends of the couples led to a mercury switch, by which any one of them might be quickly connected with a second copper wire leading to the potentiometer.

With a comparison cell having an E. M. F. of 2 volts and with about 200 ohms in the circuit, the wire of the potentiometer 2^m in length gave about 1^{cm} for a difference of 1° C. in the temperature of the thermal junctions. The galvanometer was sensitive enough to determine with ease the balance within less than a millimeter on the bridge wire, and the temperatures of the junctions were certainly determined within 0·1° C.

The thermopiles were calibrated after the prism had been taken to pieces, by removing the junctions from the slabs to a frame immersed in an oil pot, which contained a standard thermometer* and was placed in a water bath which could be brought to various temperatures up to nearly 100° C. That this was a safe proceeding appears from a paper printed last year in this Journal.†

In conducting the experiments the steam was passed through the steam box continuously; the upper box packed with ice and water, and the stirring apparatus started.

Readings on the potentiometer were made at intervals, until each of the thermopiles had attained a fixed temperature. This state was reached after from five to eight hours, and continued as long as the conditions were properly maintained, the indications of the thermopiles remaining satisfactorily constant for hours. The reading of all the 12 thermopiles, when some skill had been attained, required about 3 minutes.

A prism of this sort was heated many times while we were perfecting‡ our apparatus for the determination of absolute thermal conductivities, and the following is given as showing the nature of the consistent results thus obtained:

Interspace.	Distance in millimeters from the bottom of the Cold Box.	Temperature.
1	10·3	17·1
2	21·0	32·8
3	31·9	48·3
4	42·9	62·5
5	54·0	75·8
6	64·7	89·4

* Our final standard was Tonnelot No. 11,142, upon which a very complete set of tests has been made at the International Bureau of Weights and Measures.

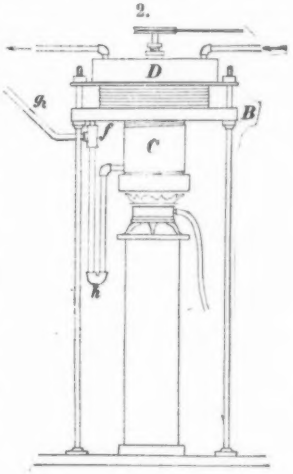
† Vol. xlviii, pp. 302-306.

‡ We are much indebted to Mr. G. W. Thompson, the mechanician of the Jefferson Physical Laboratory, for the skillful help which he gave us in this work.

From this preliminary investigation we drew the conclusion that the conductivity of our specimen of marble was practically constant between 0° and 100°. On plotting the curve it appears that the apparently greater conductivity at higher temperature is due to a real difference of conductivity at all temperatures between the four hotter and three colder slabs, though all were cut from a single block of white Carrara marble.

Readings were occasionally taken of thermopiles in the different interspaces placed within 2^{cm} or 3^{cm} of the edges of the slabs. The agreement was so close with those taken at the middle of the slab that it was evident that the law of temperature distribution on the edges exposed to the air was such that a much smaller slab might have been used.

In order to extend the limit of our investigation to higher temperatures we were obliged to make some changes in the details of our apparatus. The use of a slab 30^{cm} square made it possible to construct a much more convenient apparatus, which is shown in fig. 2. As it was not intended to observe the absolute conductivity, the troublesome ice box was replaced by a closed iron drum, D, containing a rotary stirrer and scraper turned by a motor. A large volume of water, upwards of 20 kilograms per minute, flowed through the drum, D. Special arrangements for obtaining a large supply of water at a constant temperature were at our service in the laboratory, but a simple connection with the city supply gave us a very uniform temperature of about 20°.



The hot chamber was the iron box, B, planed on its upper surface and communicating at the bottom with a retort chamber, C, in which about 20 kilograms of mercury were kept boiling. The outlet at *f* allowed the vapor to escape to the tube *g* connecting with a large wrought iron chamber, where it condensed and flowed back into the retort through the trap *h*.

It was thus found possible to maintain a temperature of about 355° C. for many hours at a time. A very elaborate system of inch-thick asbestos jackets was found necessary on the hot box and all parts of the distilling apparatus. This is not shown in the figure. The arrangement of the thermo-

piles was the same as in the larger apparatus. They were made, however, of much smaller wire, only $0{\cdot}1^{mm}$ in thickness, and, owing to the difficulty of keeping our platinoid free from kinks, we made use of German silver. As soft solder melts at too low a temperature and it is not easy to use hard solder on such small wire, the junctions were made by electroplating the wires together with copper.

The calibration was accomplished by heating the junctions in a large iron, triple-walled, quadruple-jacketed stove in the near vicinity of a platinum coil, the resistance of which was used as a standard of comparison. The resistance of the platinum coil at various temperatures was determined by placing it (either directly or enclosed in a thin tube of glass or metal) in ice, steam, and the vapors of chemically pure anilin, napthalin, diphenylamine, mercury, etc. A curve thus obtained gave the relation between resistance and air thermometer temperatures. Direct measures on several thermopiles were made at the same time and in the same manner, by immersing them in the different vapors. It was necessary to reduce the current flowing through the potentiometer (2 meters in length) so that 1^{cm} corresponded to 2° C. A temperature difference of 0·1° in the junction was still easily visible.

Various heatings were made with marble cut from two of those slabs which the first experiment had shown to be of nearly equal conductivity. It was much easier with the smaller size of slabs to obtain smooth surface and uniform thickness. The following is a specimen of the results obtained:

Dist. in millimeters from Cold Face.	Temperature.
0·0	39·5
10·9	78·5
21·8	117·4
32·7	157·1
43·6	198·9
54·5	235·6
65·4	271·8
76·3	310·7

In order to obtain the temperatures on the outsides of the extreme slabs, a layer of asbestos paper was interposed on each side between the iron plates and the marble, so that the total fall of temperature in the marble is some 60° less than the difference in temperature of the hot and cold chambers.

A curve plotted from these observations shows that the temperature gradient was practically uniform throughout the whole range.* A similar curve taken with the slabs in reversed order gave the same result. The different slabs, though cut from the same block of marble, differ slightly in conductivity,

* It will be seen that this agrees with results obtained by Dr. Robert Weber (Nature, March 7, 1895, p. 439).

but we can find no evidence of change of conductivity with the temperature.

In order to form an estimate of the difference in temperature between the adjacent faces of two slabs separated by one of the interspaces, we made a series of experiments by increasing the width of one of the spaces by various amounts. We found that this difference increased rapidly with the width of the space, being about 10° C. for a space 1^{mm} wide and nearly 30° for a space $1{\cdot}65^{mm}$ wide. Our observations seemed to show that the temperatures on two sides of a crack $0{\cdot}2^{mm}$ wide did not differ by so much as 2° C. and that the thermal junction gave either temperature within 1° C.

Two sets of experiments were made with the second form of apparatus upon slabs cut parallel with the cleavage from the same block of slate. Although further measurements, which we hope to make soon by other methods, are desirable, our results seem to indicate an increase of conductivity of about 30 per cent between 70° C. and 300° C. They are as follows:

Distance in millimeters from the Cold Face.	Temperature in Case I.	Temperature in Case II.
0·0	49·5	45 5
9·9	91·6	96·1
19·6	128·8	140·5
29·4	161·0	182·5
39·2	196·0	219·9
48·9	229·6	258·9
58·8	260·5	295·0
68·9	291·2	333·1

The range of temperature in the second series was increased by decreasing the thickness of the sheet of asbestos between the hottest slab and the iron plate next it.

Our acknowledgments are due to the American Academy of Arts and Sciences, who have made an appropriation from the Rumford Fund in aid of our work.

The Jefferson Physical Laboratory, Cambridge.

ART. XLVIII.—*Central Michigan and the Post-Glacial Submergence;* by E. H. MUDGE.

FROM time to time during the past four or five years articles from the pen of Dr. J. W. Spencer, in advocacy of the theory of a great depression and submergence of the great lake region at the close of the glacial epoch, have appeared in this Journal. Dr. Spencer's conclusions are based principally upon the position and deformation of what he considers to be deserted high-level beaches in the vicinity of the great lakes. Whatever may be the value of the theory with reference to the eastern part of the lake region, I have been quite unable to harmonize it with certain phenomena in central Michigan. While I have no desire to detract from the real value of Dr. Spencer's labors, I wish to call attention to the conditions which here exist.

Across the Michigan peninsula, from the mouth of Grand river on the west to Saginaw bay on the east, there is a marked depression or valley. It is evidently the unfilled portion of a much deeper valley, eroded in pre-glacial times by Spencer's Huronian river. The conditions to be considered are found in connection with a portion of this depression, extending from the watershed in Gratiot county to the vicinity of Grand Rapids, a distance of about fifty miles. Through this entire distance, except near the watershed, the lowest part of this depression is occupied by a wide river valley, the dimensions of which are much greater, in proportion to the size of the stream occupying it, than those of any other river valley in the state. Its principal features must be noted. Its average width is perhaps two-thirds of a mile, and throughout its length, except where broken down by the entrance of tributaries, it is bordered by steep drift bluffs averaging fifty feet in height. The present flood plain is broad and flat, and a well-marked terrace is usually present above it. The conditions are such, in fact, that there can be no doubt that this valley was excavated in the drift by a stream much larger than that which now meanders through it. Whence came this greater stream?

Grand river, rising far to the south, enters the wide central valley at a point in the eastern part of Ionia county. Above this point its valley is narrow and exceedingly crooked, without terraces—features denoting comparative newness, and in striking contrast with the greater valley which it here takes possession of. As the central valley, with its characteristic features as above described, extends far to the east of this

point, as well as to the west, it is clear that the Grand was not the agent of excavation.

I have heretofore* adopted the theory that this central valley owed its origin to the presence of a strong glacial stream, supplied by the wastage of the Saginaw valley glacial lobe, as laid down on Prof. Chamberlin's glacial maps. If, however, this territory was deeply submerged during the period of glacial disappearance, no such glacial stream could have existed.

Dr. Spencer hints† that the direction of the drainage of this region after its emergence was towards the east, but that it was afterward reversed by the eastward differential elevation of the country. This conclusion is based on the differential elevation of the Ridgeway beach, which he calculates at a little less than one foot per mile across the region in question. "From Grand Rapids to Pewamo," he says, "the beach passes through a strait between high lands on both sides," although it is not identified at any point between the places mentioned, an interval of fifty miles. Let us compare the elevation of this beach with other known elevations. The elevation of the D., L. & N. railway track at the Ionia station, on the valley bottom, is 658 feet. The general level of the country immediately adjoining the valley margin is 50 feet or more higher, making the elevation probably more than 710 feet. The nearest point at which the beach has been identified is at Pewamo, 12 miles to the east, where its elevation is placed at 724 feet. As the beach descends to the west at the rate of nearly one foot per mile, its elevation at Ionia must be about 10 feet lower, or 714 feet. This practically coincides with the level of the valley margin, as above calculated. Now the declivity of the central valley throughout the 50 miles is a little less than one foot per mile—almost exactly equivalent to the westward slope of the Ridgeway beach. It follows, therefore, that when the beach was formed, the river valley throughout its whole length was also level, and if it then existed it was filled just even full of water.

It may be contended that it was at this period that the valley was excavated. The drainage from the adjacent territory on either side would be sufficient to create a gentle current, and the direction of flow would necessarily be to the east, toward the open sea. However, as the eastern and western bodies of water were joined into one at the north, the current must have been extremely feeble—quite incapable of performing the work. Besides, I have found evidence which

* "Observations along the Valley of Grand River," Am. Geol., Nov., 1893; and "Drainage Systems of the Carboniferous Area of Mich," Am. Geol., Nov., 1894.

† This Journal, March, 1891, p. 208.

seems to me to prove conclusively that the agent of excavation was a powerful westerly-flowing stream.

On section 23 of Ionia township (T. 7 N., R. 6 W.), the excavation of the valley has uncovered a ledge of Carboniferous sandstone, the only rock exposure along this line between Grand Rapids and the Saginaw valley. It is, perhaps, a portion of the cliff overlooking the ancient Hurorian valley. At its eastern or up-stream edge the rock rises abruptly to the height of four or five feet above the adjacent silt bottom lands. Over a considerable area, perhaps 40 acres, the level surface of the rock is exposed, or covered with only a few inches of sand, with occasional granite bowlders up to two feet in diameter scattered about. The down-stream extension of the surface is hidden by a gradually thickening mass of sand and gravel, and it is to the form and position of this mass that I wish to call special attention. From the exposed rock surface it rises very gently to the west, or down stream, for a distance of more than a mile, terminating with a rounded front sloping down to the valley bottom. Its lateral diameter is perhaps one-half a mile. The river flows along the north side, with 40 rods of silt land intervening, while that part of the valley to the south is occupied by a long, narrow strip of swamp land, with black vegetable mould several feet in depth. This elevated tract, near its western end, attains an altitude of about 20 feet above the flats. A railroad cut ten feet in depth at this point shows it to be composed almost entirely of coarse, unstratified gravel. The surface is exceedingly stony, and many large bowlders are found along the northern margin.

The presence and position of this elevated tract within the river valley possesses great significance. It can scarcely be doubted that the river, in the process of lowering its valley, denuded the rock above mentioned, which formed an obstruction in the way of further excavation of the middle of the valley. The force of the stream being thus broken and deflected to either side, this long elevated strip was left stretching down the valley from the rock barrier, and received its evenly rounded contour from the influence of the overflowing waters. Only a large and powerful stream could have produced these conditions, and it is equally plain that this stream flowed to the west.

The problem is to harmonize these deductions with the fact of a general submergence of this region during the close of the glacial epoch. What and where was the source of supply of the powerful current that shaped and moulded the central valley? If no such submergence ever existed, the theory of a glacial origin satisfies all the conditions most perfectly. But if at the close of glacial time this surface was depressed below

sea level and flooded with water, the theory must necessarily be abandoned. We can scarcely assume that such depression and submergence did not take place until some time after the disappearance of the glacial sheet, thus affording an opportunity for the valley to be formed in the manner above suggested, for all the known evidences lead to the opposite conclusion. Neither can it be held that the large stream necessary for the work was the result of a much heavier rainfall, in the period following the subsidence of the waters, than at present. Such a course would have resulted also in a corresponding enlargement of the upper Grand river, whose drainage area is much greater than that tributary to the portion of the wide central valley east of its junction with the Grand. The narrow and tortuous upper Grand valley indicates no such enlargement. On the contrary, it especially disproves it. The conditions which produced the large central stream appear to have affected none of its tributaries.

It will be readily seen, therefore, that the submergence theory, in order to fulfill all requirements, must provide an adequate source of supply for so powerful a stream as above indicated; and such source of supply must of necessity be placed either upon or to the east of the Grand-Saginaw watershed. The task is more than I have been able to accomplish.

Ionia, Mich.

ART. XLIX.—*On some Devices for the Separation of Minerals of high specific gravity;* by S. L. PENFIELD.

MINERALOGISTS and petrographers are certainly greatly indebted to Dr. J. W. Retgers* for the fortunate discovery that the nitrates of silver and thallium, when mixed in the proportion $AgNO_3 : TlNO_3 = 1 : 1$, yield a double salt which fuses at about 75° C. to a clear mobile liquid, having a specific gravity of over 4·5 and capable, while melted, of being mixed with water in all proportions. The material is easily prepared by dissolving a weighed quantity of thallium in nitric acid, evaporating on the water bath until the excess of acid is expelled and then adding sufficient silver nitrate to make a double salt of the composition given above (8·33 grs. $AgNO_3$ to every 10 grs. of thallium). The salt is readily soluble in warm water and may be reclaimed by filtering the solution and evaporating it on the water bath to its maximum concentration, care being taken as far as possible to avoid dust and impurities.

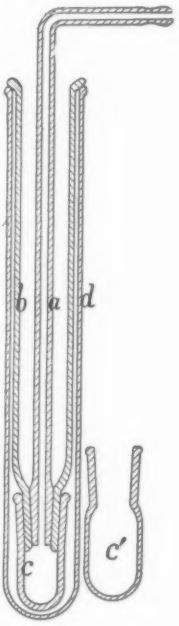
As recommended by Retgers, the operation may be performed in a test tube heated in a water bath, and after the separation is completed the fusion is allowed to cool, when the salt solidifies with the heavier mineral grains at the bottom and the lighter ones on top. On breaking the test tube and dividing the mass the separated minerals may be obtained by dissolving in water. The operation cannot well be performed in the ordinary glass stop-cock separating funnel, and there are disadvantages in using test tubes, because, if in an operation one desires for any purpose to obtain the heavy material which may have separated out, one must interrupt the whole process, while again if considerable water has been added and one is working with the liquid when the specific gravity ranges from 3 to 4 the fusion or solution does not yield, on cooling, a solid cake, but a mass of wet crystals, which it is rather unpleasant to manipulate.

A simple glass stop-cock device, by means of which successive portions of the heavy material can be drawn off from the bottom, has been described by D. A. Kreider and the author,† but a still better apparatus can now be recommended. The idea is not an original one, but was suggested by an apparatus devised by Contollence and exhibited to the author by Prof. F. Fouqué at the Collège de France, Paris. As modified for use with the Retgers double salt it is shown in section, about

* Jahrb. f. Min., 1893, i, p. 90.
† This Journal, III, xlviii, p. 143, 1894.

one-third natural size, in the accompanying figure. The glass tube *b*, about 20^{cm} long by 2·2^{cm} internal diameter, is narrowed below and fitted with well ground joints to the cap *c* and the hollow stopper *a*, and these parts fit loosely within a large test tube *d*. For holding and heating the apparatus the author has found it convenient to make use of a metal test-tube stand, made so as to fit inside of a tall beaker filled with hot water.

1.



When a separation is to be made it is best to previously melt the double salt in a dish or casserole on the water bath until it becomes perfectly clear and to dilute it with water until it is approximately of the specific gravity of the minerals to be separated, when, the stopper *a* being removed, the liquid is poured into the warm separating apparatus until the tube *b* is about one-half full. The mineral powder is next added, and thoroughly mixed, which may readily be accomplished by blowing a stream of air into the liquid through a small glass tube, and then successive portions of water are added until the desired separations are effected. To obtain the heavy material in *c* the stopper *a*, previously warmed, is inserted, when *c* can be removed and washed out with hot water. By replacing *c*, withdrawing *a* and adding more water another portion can be thrown down and separations made almost as quickly and easily as with the ordinary stop-cock separating funnels. When one has had a little experience in using the Retgers liquid and the apparatus, almost the only disadvantage that will be found is that specific gravities cannot be taken with the Westphal balance, while the decided increase in specific gravity over the other heavy liquids makes it exceedingly useful. When it is necessary to work with large quantities and to throw down a considerable quantity of some heavy material, it is best to have a second apparatus with a larger lower reservoir, *c'*, fig. 1, but it will be found that this is not so convenient for ordinary use as one where *c* is small.

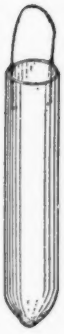
In a separation which the author undertook of some monazite sand, it was found that the Retgers double salt was not quite heavy enough to float some zircon and chromite crystals, and an attempt was made to obtain a higher specific gravity by varying the proportion of silver and thallium nitrates. Accord-

ingly preparations were made having the following proportions: $AgNO_3 : TlNO_3 = 3:4$, 2:4 and 1:4, and separations with these were made in test tubes. The 3:4 preparation fused below 100° C. and on it most of the zircon and some of the chromite floated, the specific gravity of the separated product being 4·678. The 2:4 preparation was fused in an air bath* heated to 150° C. and on it the remainder of the zircon and some chromite floated, sp. gr. 4·78. The 1:4 preparation was fused at about 200° C. and on it some chromite floated, sp. gr. 4·85. Lastly thallium nitrate was used, when the temperature of the air bath had to be about 250° C. and a final product of chromite was separated having a sp. gr. of 4·94, while only a few dark grains were left with the monazite. Thus in cases of emergency a supply of the above mentioned preparations, enough to make from 5 to 10^{cc} of fused material, may be found convenient.

An attempt was made to separate chalcopyrite, sp. gr. = 4·2, from linnæite, sp. gr. = 4·85, but it was found that the minerals were attacked by the Retgers liquid. Pyrite is also attacked, and it is evident that it is not safe to apply this method to the separation of sulphides, although it may answer in some cases.

In taking the specific gravity of separated mineral fragments the author believes that in many cases the following method will be found more convenient and simpler than the pycnometer. The fragments, boiled in water to expel air, are transferred to a tube with a loop of platinum wire fused into the glass for a handle, shown in natural size in fig. 2, and when suspended by a fine platinum wire the weight in water can be taken on a chemical balance. The powder is then transferred to a watch glass by means of a jet of water and its weight ascertained after drying, while the tube is weighed empty in water. The narrow tube is more favorable for weighing in water than a pan would be, as it offers less resistance to the swinging of the balance.

2.



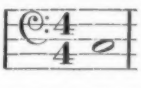
Separating apparatus according to the author's drawings have been made by the firms Alvergniat Frères, 10 Rue de la Sorbonne, Paris, and by Messrs. Eimer and Amend of New York.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School, New Haven, October, 1895.

* One described by J. H. Pratt and the author is a convenient form to use. This Journal, III, xlvii, p. 83, 1894.

Art. L.—*How to find the Key Note of Auditoriums;* by Ephraim Cutter, M.D., New York.

In a former paper the principle of air physics was laid down that oratorical phonation should be in the *key note* of the auditorium, as the oripulations (os = mouth) of speech are the same as those of song and as the basic vowel sounds are the same in speech and song. Since then an English writer has demonstrated that vowel sounds in speech are musical tones. Complying with a request from a teacher of physics, I will try to give some directions for ascertaining the key note of auditoriums.

I. Sing the major scale of C  or = 100 *m*, in a rostrum position facing the audience or empty auditorium. Use care to sing each note with the same power; that is, with a medium voice uniformly as to loudness. Then observe which note is more resonant than any other note (only if the observer sings let him or her not get excited). This note is the key note. Test by singing this note near a piano with damper raised. If the piano answers back better to this note than any other note (for the chords and over-tones will be heard) it is the key note.

Tune an instrument of the violin family so that one of the open strings will be in the supposed key note: then sing it and the instrument will respond audibly.

II. If an organ is present play the scale of C natural on the pedal diapason alone, giving each note an equal force. Observe which note is most resonant and this note will be the "key note," to be tested as above.

III. Or play this C major scale on an open piano and note carefully the effect. When the key note is struck there will be a liquid reedy tone imitating an organ tone. This is the key note.

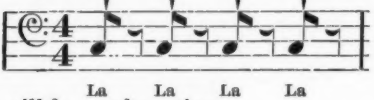
IV. Another way practised by Senator W. M. Stewart and (it is said) by Cicero, is to station a man at the other end of the auditorium, who raises his hand and lowers his hand according as the voice rises and falls but keeps it stationary when the voice is best audible, and the speaker then voices his utterances in that key note. The Senator says he did this not knowing this rationale, and Cicero was probably in the same condition.

V. When on the platform, the way the writer tells if he has struck the key note is to observe the effect on his audience and himself. The most common key note of auditoriums is F . He usually begins in that key. If it is the key

note, only three or four words suffice as to the audience, which shows by attitude and attention that it hears what is said. Three or four words suffice to the speaker, because he finds that he speaks with ease and feels his voice to impinge on the farthest walls. If he does not find these results his pitch is raised or lowered till he obtains them. Strange as it may seem, the effort of getting and keeping the key note takes away the stage anthrophobia so apt to attack medical men who occasionally orate and who perhaps are about the poorest educated speakers to be found.

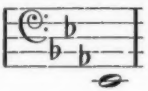
VI. A scientific way would be to take into the auditorium a siren or, better, what might be termed Professor Papin's electrical siren. Start it at 120 vibrations per second and then add one to each tone until the octave of 240 vibrations is reached if necessary. The most resonant tone should then be distinguished and the exact number of vibrations given with less of error than with organs or pianos, whose notes may vary from the standard; so much so that one may strike a piano or organ that has no note exactly corresponding with the key note, but a stringed instrument, where the tones are made by the fingering, can obviate this difficulty, as with a 'cello.

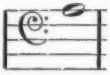
VII. Having the key note of song, to determine that of phonation, simply sing *La* or other words staccato, that is, very short with a rest between. For example, *M* 100 = ♩



then a little faster and you will have phonation.

VIII. Having the phonation key note, to get the singing note it is only needful to prolong the basic vowel sounds somewhat as in intoning in church. Always bear in mind that the basic vowel sounds are musical tones in both song and speech. Sometime there will be rules for phonational harmony as there are now for musical harmony. Then speech may be as sweet as song.

Illustrations as to Direction I. This was sung in my parlor at Buena Vista Ridge and the key note was found to be E flat, which was sung or vocally played (i. e. sung without words as one plays on an instrument: if the human larynx is not a musical instrument to play on there is none) on before an open piano, which responded in E flat and its over-tones. "Father," said my son Edward, "I could feel the floor vibrate while we were playing Haydn's trio No. 5 for piano, 'cello and violin in E flat. Sounding  on the 'cello alone, the floor

vibrated again. Now the piano was tuned below concert pitch, hence this key note was not exactly E flat, I think it was D natural of concert pitch. But this discrepancy need cause no more confusion than the differences between mean and sidereal time. In my room at Yale, South Middle College, 1849, when I sang  the A string of my 'cello, standing in a corner, would answer back.

As to Direction II. About 1850, Mr. Simmons, an organ builder of Boston, was tuning a 16-foot pedal stop which was added after an organ was built at his factory. It was in the church auditorium. All went smoothly save the F natural pipe. Do what he could, it rounded out into a far stronger tone than any of the other pipes and made the octave uneven. He finally gave it up. Ever afterwards, as long as this organ remained there, it rendered music written in the key of F natural with a harmonic power that made the air outside and inside ring. F was the key note of the auditorium. When a window rattles while the organ plays it thereby announces the key note of the room or its chords. The key note is more resonant than its chords, as a musical ear soon detects.

As to Direction III. I heard this exampled at a faculty concert of the N. E. Conservatory, Boston, Professor Faelten, Director, playing.

As to Direction IV. It is probable that Cicero was a good student of physics.

As to Direction V. Examples: 1888, Cincinnati Music Hall, capacity 6,000. At the Section of Medicine, Am. Med. Association, audience of 200 estimated. The key note was thus found to be F natural. The speaker was heard perfectly, spoke with ease and though tired at the outset was rested at the close!

1889, Leeds, Albert Memorial Hall. Banquet of the British Medical Association, 700 plates. A bad acoustic auditorium. A very few words in the key note F, thus found, were followed by loudest applause and post prandial congratulations from several elderly gentlemen, who thanked the speaker "because we could hear what was said."

1890, Berlin International Congress, Sections met in picture galleries. Securing the key note secured close attention. Professor A. P. Clarke, M.D., Dean of the College of Physicians and Surgeons, Boston, was reading a paper at this Congress, when some one said "louder" in the key note of the gallery; he changed his voice at once to this note and read satisfactorily.

Remark. This idea thus presented grew out of the biological study of music as a property of air. The physiology of speech includes its best use.

October 1, 1895.

Art. LI.—*Stratigraphy of the Kansas Coal Measures;* by Erasmus Haworth. With Plate IX.

Areal Extent.—The eastern fourth of Kansas is covered with Coal Measure rocks. A small triangular area of about thirty square miles, lying in the extreme southeastern corner of the state, is covered with the Mississippian formation. The western limit of the Coal Measures has not yet been fully determined, as the line between the Coal Measures and the Permian has not been definitely located. From paleontologic evidence, according to Prosser*, it is above the Cottonwood shales, but probably less than a hundred feet, so that the eastern limit of the Cottonwood Falls limestone is rarely more than ten to fifteen miles east of the western limit of the Coal Measures, and in many places the two are only a few rods apart. The limits of this limestone are now pretty well known, having already been published,† subject to correction, in map form. Approximately the four eastern tiers of counties lie east of this limit, which would give about nineteen thousand square miles for the Coal Measure area.

The Floor.—The Coal Measures rest directly upon the Mississippian formation, which extends at varying depths below the surface far to the westward. The recent extensive prospecting for oil and gas in the southeastern part of the state has made it possible to study the position and character of the floor to a great extent. In the extreme southeast corner of the state, in the vicinity of Galena where it covers the whole surface, the hill tops are a little over a thousand feet above the sea level. The Coal Measures approach to within four miles of the east state line opposite Galena. The Mississippian surface declines to the west, so that at Oswego, where it has been reached by at least two wells, it is about 500 feet below the surface, or about 400 feet above sea level, which is a decline of fully 475 feet from the valleys along the eastern part of the state twenty five miles away, or of about 600 feet from the hill tops, giving an average decline of about twenty feet to the mile. Wells at Stover and Mound Valley did not reach the Mississippian, but at Cherryvale, fifty miles away, it was reached 1008 feet below the surface, which places it 180 feet below sea level. As this well was made with a diamond drill and an excellent core preserved,‡ there can be no reasonable doubt

* Journal of Geology, vol. iii, p. 702.

† Haworth, Kan. Univ. Quart., vol. iii. pp. 271–309.

‡ This core has recently been lodged in the museum of the University of Kansas in a well preserved form, where it can be examined by any geologist wishing to do so.

about the correctness of these figures. This gives a westward inclination of more than twenty feet to the mile. At present we have no definite data regarding the depth to the surface to

the Mississippian west of Cherryvale. A well three miles west of Independence reached 1100 feet without striking it, one at Niotaza 1158 feet, and one at Wichita 1950 feet, so we

can only say it lies below these several depths at the respective places. To the northwest it was reached at Neodesha 135 feet below sea level, at Fredonia 310 feet, and at Fall River 430 feet below sea level, giving a little less than a twenty-foot decline to the northwest. At Osage Mission, thirty nine miles from Galena, a well 700 feet deep failed to reach it. At Chanute, fifty-eight miles away, it was reached 36 feet below sea level, and at a few other points in that vicinity at similar depths. The decline from Galena to Chanute, straight northwest, is consequently about sixteen feet to the mile, considerably less than in a more westerly direction. Northward along the east line of the state it was reached at Girard 493 feet above sea level, at Fort Scott 385 feet above sea level, at Pleasanton 206 feet above sea level, at Paola* 182 feet below sea level, at Kansas City at sea level, and at Leavenworth over 300 feet below sea level. A well 1638 feet deep, or about 775 feet below sea level, at Topeka failed to reach it. The inclination from Galena to Kansas City is, therefore, only about 6·5 feet to the mile. But as the southeastern boundary of the Coal Measures is a line running northeast and southwest, the latter points should be reckoned not from Galena, but from the nearest points of surface exposure of the Mississippian. According to the geological map of Missouri published by Winslow,† the Mississippian occupies the surface at Sweet Springs and a few miles to the west, bringing it to within 50 miles or less of Kansas City. Reckoning in this way, we have a decline of the floor from near Sweet Springs to Kansas City of about 15 feet to the mile, and to Topeka about 14 feet, how much more we cannot say, which is considerably less than the decline along the southern line of the state. From the above data we can calculate the decline in any direction. From Kansas City to the southwest we find almost a level in the floor towards Chanute and Cherryvale.

From these and other similar data we may conclude that the Mississippian formation underlies all or nearly all of the Coal Measures in Kansas, and that its upper surface is strongly inclined westward, equaling 20 feet to the mile for the first fifty miles along the south line of the state, and at least 10 feet to the mile for the whole distance to Wichita, and probably more, while to the north as far as Kansas City the inclination averages only about 6·5 feet to the mile, and an intermediate value in intermediate directions. According to Winslow,‡ in a direc-

* A little doubt has been expressed regarding the correctness of this well record. The record used is preserved in the City Public Library at Paola. The criticism is to the effect that the Mississippian comes about 200 feet nearer the surface, which would correspond better with its depth at Pleasanton and Kansas City.

† Preliminary Report on Coal, 1891, and succeeding volumes.

‡ Ibid, p. 24.

tion northwest from Sedalia the Mississippian floor declines about 1600 feet in 150 miles, or a little more than 10 feet to the mile, but he gives no data regarding the inclination in other directions.

*The Cherokee Shales.**—Immediately overlying the Mississippian floor, and slightly nonconformable with it, are heavy beds of shale which here and there grade into sandstone. In thickness they vary from 350 to more than 700 feet. They are known to extend under the entire area within the state where oil and gas prospecting has been conducted, every well record yet examined showing them so prominently that no doubt can be entertained regarding their existence. At Oswego they are about 450 feet thick, at Cherryvale 415, at Neodesha 425, at Osage Mission more than 415, at Chanute 425, at Paola 750,† at Kansas City 427, at Leavenworth 540, and at Topeka not less than 700, but as the Topeka well did not reach the Mississippian we do not know how much thicker they are. The record of the Wichita well and other wells in the west have not yet been examined by the writer, but from the great and uniform thickness of the shales at the points named, varying from fifty to over a hundred miles from the nearest surface exposure of the Mississippian, it would seem they constitute an important geologic formation, having an extent oceanward from the ancient shore line as it existed during early Coal Measure time equalling that of other formations of similar thickness occurring at different places in the general geologic column. With a thickness of over 700 feet at Topeka, sixty five miles west of Kansas City, where they are only 427 feet, it appears they are thickening westward. We may reasonably suppose, therefore, that they extend at least a hundred miles beyond.

The Cherokee shales extend southward from Kansas into the Indian Territory an unknown distance, and to the northeast into Missouri and probably across into Iowa. The records of a few recently drilled wells in Missouri north of the Missouri river have been examined, each of which shows them to maintain their thickness quite well. Broadhead has published many well records and sections from Missouri, both north and south of the Missouri river, every one of which shows the existence of a heavy shale bed at the base of the Coal Measures. Similarly one generally exists at or near the base of the Coal Measures wherever they occur in America, and for that matter all over the world, and frequently constitute the whole of the lower Coal Measures, although they do not in Kansas, as will be shown later in this article.

* Haworth and Kirk. Kan. Univ. Quart., vol. ii, p. 105, Jan., 1894.

† See foot-note, p. 454.

In character the Cherokee shales vary greatly both vertically and laterally. Portions of them are bituminous, portions are argillaceous, and arenaceous. In color they are as variable as in composition. Some are almost a jet black, others a light grey, and others representing the various colors usually characteristic of Coal Measure shales. They are exceedingly rich in coal, producing at the present time more than two-thirds of the whole amount mined within the state, supporting all the mines in the vicinity of Weir City, Pittsburg, Cherokee, and to the northeast to Arcadia, as well as those about Fort Scott and at Leavenworth. The well records to the west show frequent veins of coal. At Cherryvale a twenty seven inch vein was passed about fifteen feet above the base and several lesser ones above. At Topeka eleven veins were passed, while every well record examined shows three or more.

Here and there throughout the Cherokee shales greater or lesser beds of limestone occur, usually from six to fifteen inches in thickness and of very limited lateral extent, but occasionally four or more feet, although none of them seem to have sufficient lateral extent to be of importance stratigraphically. They generally contain many invertebrate fossils, from a list of which the following are taken:*

Fusulina cylindrica in extreme upper portion; *Ptilodyctia triangulata; Rhombopora lepidodendroides; Athyris lamellosa; Athyris subtilita*, found in almost every limestone in the Coal Measures; *Chonetes mesoloba; Discina nitida; Productus longispinus; Productus costatus; Spirifera camerata; Spirifera planoconvexus; Spirifera lineata; Nucula ventricosa; Schizodus ——;* (very large) *Bellerophon carbonaria; Macrocheilus primigenius; Nautilus planovolvis* (?)

The Oswego Limestone.†—Above the Cherokee shales are two limestone systems separated by from four to seven feet of an unusually black shale. Each is from five to fifteen feet thick, and they are wonderfully persistent laterally for limestones so thin. The Cherryvale well record shows that they extend that far west. To the northeast they appear on the surface in a sinuous line passing from the south side of the state to the northeast by way of Oswego, Girard and Fort Scott, near which points they cross into Missouri. Many of the different well records to the northwest show them, and quite likely they were passed in the boring at Kansas City and Topeka, although one cannot well decide regarding so thin limestones without more intervening wells. The lower lime-

* Copied from unpublished catalogue of Kansas Coal Measure fossils prepared by Rev. John Bennett, Fort Scott

† Haworth and Kirk, Kan. Univ. Quart., vol. ii, p. 105, Jan., 1894.

stone is the "cement rock" quarried and manufactured so extensively into hydraulic cement at Fort Scott.

Both of the limestones and the associated black shales are well filled with fossils, from the list of which the following are representatives. The corals and crinoids are particularly abundant and large. *Fusulina ventricosa (?); Campophyllum torquium; Syringopora multatenuata; Zeacrinus mucrospinus; Chaetetes milleporaceus*, very plentiful; *Ptilodictia triangulata*, rare; *Rhombopora lepidodendroides; Chonetes mesoloba; Productus costatus; Productus nebrascensis; Productus punctatus; Retzia mormoni; Rhynchonella uta; Spirifera lineata; Allorisma subcuniata; Aviculopecten* ———, first seen in upper limestone; *Nuculana bellistriata; Orthis carbonaria; Bellerophon montfortanus; Naticopsis ventricosa; Pleurotomaria sphaerulata; Gonetites* ———; *Nautilus ferratus; Orthoceras rushensis; Phillipsia major.*

*The Pawnee Limestone.**—In the southern part of the state a shale bed which in places reaches a thickness of 60 feet and which carries considerable coal, lies immediately above the Oswego limestone, but it seems to thin out towards the north. Above this a limestone occurs which likewise thins towards the north, but which is very prominent on the uplands around Fort Scott and to the southwest. At one place to the west of Fort Scott it reaches a thickness of 35 feet. It extends westward to beyond Cherryvale and northward to the vicinity of Pleasanton, beyond which it seems to disappear. It affords the following fossils in considerable abundance, with many others not given: *Cyathaxonia distorta; Lophophyllum proliferum; Fistulapora nodulifera; Productus longispinus; Spirifera lineata; Spiriferina kentuckiensis; Pleurotomaria sphaerulata.*

The Pleasanton Shales.†—Above the Pawnee limestone lies a shale bed of considerable importance. In the vicinity of Pleasanton and Boicourt it is fully 200 feet thick. To the south it maintains its thickness tolerably well to beyond the south line of Kansas, but perhaps not in quite as heavy beds as around Pleasanton. Northward it decreases slightly, but regains this thickness at Paola and is 180 feet thick at Kansas City. Westward it seems to maintain its thickness quite well: At Iola, according to the record of the Iola well, it is over 250 feet thick.

In places the Pleasanton shales carry much sandstone, a noted instance of which is within ten feet of a summit at Boicourt. Here extensive quarry operations were once conducted. They carry two coal veins equalling from twenty-

* Swallow, Geology of Kansas, 1866, p. 24.

† Haworth, Kan. Univ. Quart., vol. iii, p. 274, April, 1895.

four to thirty four inches in thickness, from which all of the Linn county coal is obtained; also they frequently have sufficient calcareous material to produce thin limestone beds, that are always well filled with fossils, from which the following are representatives: *Cyathaxonia distorta; Athyris trinuclia*, very rare; *Chonetes mesoloba*, last seen here; *Discina nitida*, becoming rare; *Rhynchonella uta.*

*The Erie Limestone.**—Above the Pleasanton shales a group of three principal limestone systems are met with which in places are so close together that they can well be described as one, but which to the south diverge vertically so much that near the south side of the state their lines of outcropping are ten to twenty miles apart. From the vicinity of Union Town west of Fort Scott northward to Kansas City they are rarely more than ten to twenty feet apart vertically and often much less. Southward, where they diverge so greatly, local names have been used for each member; their use is purely local and geographic. The upper one of the three is considerably the more important. It thickens rapidly westward from the vicinity of Cherryvale, where it caps the hill tops to Independence, where it is from thirty to forty feet thick. In places it has been extensively quarried and is quite well known as the Independence limestone. The lowermost member of the three seems to be the same as the Bethany Falls limestone of Broadhead,† number 78 in his section.

These limestones have a great lateral extent, reaching from the south line of the state to Kansas City, from which point, according to Broadhead,‡ they extend northward to the Iowa line, and according to Keyes,§ from there almost entirely across the state of Iowa, making them an unusually extensive limestone formation. Westward they reach as far as the deep borings made in Kansas. They abound in fossils, from the list of which the following species are selected: *Fusulina cylindrica; Axophyllum rudis; Campophyllum torquium; Archiocidaris mucronatus; Archiocidaris triserrata; Erisocrinus typus; Eupachycrinus tuberculatus; Scaphocrinus hemisphericus; Zeacrinus acanthophorus; Serpula incita; Spirorbis carbonaria; Fennestella ———; Polypora submarginata; Synocladia biserialis; Chonetes granulifera; Chonetes smithi; Chonetes millepunctatus; Orthis pecosi; Orthis robusta; Orbiculoida ———; Productus americana; Productus pertenuis; Productus symmetricus; Syntrilasma hemiplicata; Terebratula bovidens; Allorisma gra-*

* Haworth and Kirk, Kan. Univ. Quart., vol. ii, p. 188, Jan., 1894
† Broadhead, Mo. Geol. Rep., 1872, part ii, p. 97.
‡ Loc. cit.
§ Keyes, this Journal, vol. l, p. 243, 1895.

nosa; Allorisma reflexa; Allorisma subcuneata; Aviculopecten carboniferus; Aviculopecten interliniatus; Aviculopecten providencensis; Aviculopecten americana; Chaenomya leavenworthensis; Conocardium obliquam, very rare; *Edmondia aspinwallensis; Edmondia ovata; Edmondia reflexa; Macrodon carbonarius; Monopteria gibbossa; Myalina subquadrata; Myalina swallowi; Nucula parva; Pinna paracuta; Pleurophorus oblongus; Schizodus wheeleri; Solenopsis solenoides; Bellerophon crassus; Loxonema rugosum; Naticopsis gigantia; Platyceras nebrascense; Pleurotomaria broadheadi; Pleurotomaria speciosa; Pleurotomaria turbiniformis; Peupa vitusta; Conularia crustula; Goneatites lyoni; Nautilus occidentalis; Nautilus ponderosus;* etc.

*The Thayer Shales.**—Above the Erie limestone in the southern part of the state heavy shales occur which in Neosho, Wilson, and Montgomery counties reach a maximum thickness of over 200 feet, but which grow thinner northward until they become less than 30 feet in thickness. They are prominent from Chanute to the southwest and constitute the main mass of the bluffs along the Verdigris and Fall rivers from Benedict and Fredonia southward to beyond Independence. They have been passed through by every prospect well in this part of the state west of their outcropping, so that we know they extend many miles westward under the superimposed strata. They frequently grade into sandstone, so much so that many workable quarries of that rock are found here and there over the country. Ripple marks and other indications of shore deposits are frequently found in the sandstone and arenaceous shales. They also carry two or more seams of coal, which are of considerable economic importance.

The Iola Limestone.†—Above the Thayer shales is the Iola limestone system, the heaviest individual system in the whole Coal Measures of the state. Its outcropping is usually marked by a prominent escarpment, especially in the south, where the Thayer shales are so heavy. West of Elk City it is nearly 100 feet thick, at Iola it is 40, to the northeast it grows thinner so that in places it is perhaps not over 20 feet thick, but in the vicinity of Olathe, particularly a few miles west, it is fully 50 feet thick, while at Kansas City, where it constitutes the heaviest limestone in the bluff, it is about 30 feet thick. The borings at Lawrence and Topeka show that it is to be found in both of those localities with essentially undi-

* These shales were called the Chanute shales by Haworth and Kirk. Kansas Univ. Quart., vol. ii, p. 109, Jan., 1894, but were changed to Thayer shales, Kan. Univ. Quart., vol. iii, p. 276, April, 1895.

† Haworth and Kirk, Kan. Univ. Quart., vol. ii, p. 109, Jan., 1894.

minished thickness, so that it seems probable that it reaches many miles farther west. In places it is very fossiliferous, producing the following species with many others: *Michelinia eugeneæ; Athyris subtilita; Lingula scotica; Productus longispinus; Productus pertenuis; Spirifera camerata; Spirifera lineatus; Aviculopecten carboniferus; Pinna subspatulata; Nautilus occidentalis; Nautilus missouriensis.*

*The Lane Shales.**—Passing upwards from the Iola limestone, and leaving unnoticed in this article a shale bed from 40 to 50 feet thick and a limestone one one-fourth as great, we come to the Lane shales, which in many places reach 150 feet in thickness. They are very prominent all along the Pottawatomie river from its source to Osawatomie, and are known to extend far to the southwest. To the northeast, however, they thin greatly so that at Kansas City they are relatively unimportant, allowing the succeeding limestone to come close down to the Iola. They carry considerable sandstone, which frequently shows many ripple marks, and they show the usual gradations back and forth from shale to sandstone and sandstone to shale.

The Garnet Limestone.† — Immediately above the Lane shales are two limestones separated by from ten to fifteen feet of shales. They appear in the bluffs at Argentine and form the upper limestone westward to Eudora and have been passed by borings at Lawrence and Topeka. They cover the surface over a wide area along the Pottawatomie river and northward to Eudora and Argentine, and extend southwest across the Neosho river and probably to beyond the limits of Kansas. In places they thicken greatly. At the Lane "marble" quarries the upper one has reached the thickness of 30 or 40 feet, as it has also done about three miles east of Greeley. The most common invertebrate fossils found in them are the following: *Campophyllum (?); Fenestella (?); Synocladia biseriulis; Derbya (?); Productus americanus; Productus semireticulatus; Syntrialasma hemiplicata*, very abundant in places; *Myalina kansensis; Myalina recurvirostris; Euomphalus subrugosus; Naticopsis altonensis; Pleurotomaria tabulata, Nautilus occidentalis*, and about forty other species.

The Lawrence Shales.‡—These shales in the vicinity of Lawrence are near 300 feet thick if we let the name cover all lying between the Garnet limestone and the Oread limestone above. Occasionally a thin limestone occurs within them, one of which sometimes reaches 6 or more feet in thickness, but none of which have sufficient lateral extent

* Haworth, Kan. Univ. Quart., vol. iii, p. 287, April, 1895.
† Haworth and Kirk, Kan. Univ. Quart., vol. ii, p. 110, Jan., 1894.
‡ Haworth, Kan. Univ. Quart., vol. ii, p. 122, Jan., 1894.

to be of much consequence in stratigraphy. Southward from Lawrence they become thinner, so that along the Neosho river and to the south they gradually lose their great importance. Northward they maintain their thickness much better.

They vary greatly in character in different places. They carry a prominent coal seam, which is mined extensively in Franklin county and to a lesser extent elsewhere, especially in Douglas county and recently near Atchison. They carry a great deal of sandstone, but none of which is of a proper quality to be of much value economically. They are also particularly interesting on account of the large amount of arenaceous shales they have, almost all of which are filled with ripple marks and other indications of shore deposits. In fact from top to bottom they have such markings the most abundantly of any shales thus far passed. They also furnish excellently well preserved specimens of fossil coal plants.

*The Oread Limestone.**—Above the Lawrence shales two limestones are found averaging about 15 feet deep and separated by about 20 feet of shale. They outcrop along the tops of the bluffs reaching from Leavenworth to considerably south of Garnett and take their name from Mount Oread at Lawrence. Westward they extend as far as any drill record has been obtainable. The upper one constitutes the main limestone in the bluff at Lecompton, and at Atchison. Each of the limestones is well filled with fossils, but particularly the upper one, from which forty-nine species were gathered in a few hours time at Lecompton. The following is a partial list: *Fusulina cylindrica; Cyathaxonia distorta; Archiocidaris* —— (?); *Scaphicrionus* —— (?); *Chonetes granulifera; Derbya bennetti; Derbya broadheadi; Meekella striatacostata; Orthis robusta; Productus semireticulatus; Retzia mormoni*, large variety; *Syntrialasma hemiplicata; Allorisma regularis; Astartella* ——(?); *Avicula longa; Edmondia nebrascensis; Entolium avicula; Monoteria marian; Pleurotomaria bonharborensis; Nautilus sangamonensis; Paleocaris tipus.*

Osage City and Burlingame Shales.†—Above the Oread limestones different shales and limestones occur, none of which are of special interest in this connection until about four hundred feet has been passed. Here, near Topeka, a deposit of coal has been found that has been mined considerably. From the record of the Topeka deep well we know that this coal is more than 2,000 feet above the base of the Coal Measures. Above this one hundred feet and west of Topeka seven mines is another coal mining locality. Investigation shows that this

* Haworth, Kan. Univ. Quart., vol. ii, p. 123, Jan., 1894.
† Ibid., vol. iii, p. 278, April, 1895.

coal is in the same geologic horizon with that mined at Burlingame, Scranton, Osage City and numerous other places to the southwest, all of which may well be grouped under the name Osage coal, as the larger proportion of the mines are in Osage county. There are two heavy shale beds here, the one carrying the coal and the other lying above it constituting the main mass of the hills around Burlingame. As the two are separated by a limestone of considerable lateral extent, they have been named separately the Osage City shales and the Burlingame shales. Both shales carry considerable sandstone and present the customary gradation from shale to sandstone and the reverse. They also have many evidences of being shallow deposits, particularly the Burlingame shales, from which so many instances are known of the reptilian tracks in the shaly sandstone. Years ago Prof. Mudge shipped two or more car loads of the stone, principally to Yale University, from which Marsh* has identified the tracks as being produced by *Nanopus candatus*, and other reptiles.

The Waubaunsee Formation.† — Above the Osage City shales we have a continuous succession of limestones and shales to the base of the Permian. Prosser has proposed that the whole group be called the Waubaunsee formation and would include within it the Burlingame shales above mentioned. For the purpose of this article no details need be given. Prosser‡ has already published an interesting description of them, and the writer has contributed an article on the same subject.§ The whole formation is similar in general character to those below, only that there is a gradual transition in physical properties of both the shales and the limestones. The shale beds become thinner and assume their peculiar lighter hue, which must be observed in connection with the shales below in order to be fully understood. Here and there throughout the whole of the Coal Measure beds of shale fully as light as those of the Wabaunsee formation occur, but they are interspersed with black bituminous shales, while the latter kind are rare above. The limestone also takes on a corresponding change. The beds are thinner than below, so that the alternations of limestone and shale are more frequent, but the proportion of limestone is growing less. A peculiar light buff color creeps in, so that the novice could readily distinguish between a Waubaunsee limestone and one from below.

On the accompanying map of Eastern Kansas the surface and outcropping of the more important limestone systems is

* Marsh, this Journal, vol. xlviii, pp. 81–84, and Pls. II and III, 1894. See also Mudge, this Journal, vol. vi, 1873.

† Prosser, Journ. of Geol, vol. iii, p. 688, Oct., 1895.

‡ Ibid, pp. 682–705

§ Haworth. Kan. Univ. Quart., vol. iii, pp. 271–290.

shown, and the two vertical sections, the one the well at Topeka and the other a generalized section, will show the relative vertical positions of the different formations.

*Division of the Coal Measures.**—The ordinary custom of dividing the Coal Measures into two or three divisions is so well known that it need not be described here. In the different parts of the Mississippi Valley where such divisions have been applied there seems to have been no special reason for placing the lines of demarcation just where they were located rather than either above or below. In Missouri Broadhead† in each case used a sandstone formation which is by no means as extensive laterally as different limestones are. In Iowa Keyes‡ has laid aside the older terms "Lower" and "Upper" and has substituted the geographic names "Des Moines" and "Missouri" for what seems to be practically the same general divisions. In Kansas it has already been suggested§ to use one division plane located at the upper surface of the Pleasanton shale or the base of the Erie limestone and to employ the older terms upper and lower as adjectives placed before the name Coal Measures. These terms have the advantage of priority in American geologic literature, and should be laid aside only when more convenient and expressive ones are offered as substitutes. The location chosen for the division plane is the most strongly marked physically of any plane within the whole Coal Measures of the state. At Kansas City it leaves nearly eight hundred feet of lower Coal Measures, while this thickness is maintained or slightly increased southward. At Kansas City the division is at the base of the Bethany Falls limestone, which correspond with the division plane already chosen in Iowa to separate the Des Moines and Missouri formations.‖ In Kansas the division plane does not lie at the top of the Cherokee shales. The Oswego limestone and the Pawnee limestone both fall within the lower Coal Measures. It is probable these limestones do not extend into Iowa, but their existence in Kansas is incident to the general thickening of the different formations southward. By this mode of division the heavy coal beds in the vicinity of Pleasanton and Boicourt, second in importance only to the Weir City-Pittsburg coal, are left in the lower Coal Measures, while the coals in the Thayer shales, the Lawrence shales, and the Osage City shales are in the upper Coal Measure. As mining is now conducted, about three-fourths of the total coal output of the state comes from the lower Coal Measures.

* Haworth, Kan. Univ. Quart., vol. iii, p. 291, April, 1895.
† Broadhead, Mo. Geol. Rept., 1872, part ii.
‡ Keyes, Iowa Geol. Surv., vol. i.
§ Haworth, loc cit.
‖ Keyes, this Journal, vol. l, p. 243, Sept., 1895.

Ratio of Limestone to Shales.—In the whole of the Coal Measures up to and including the Cottonwood Falls limestone, there is about 544 feet of limestone, or a ratio of limestone to the total thickness of 1 : 5. In the lower Coal Measures there is only about 81 feet of limestone, or a ratio of 1 : 10, while in the upper Coal Measures there is about 460 feet of limestone, giving a ratio of 1 : 4·2.

Conclusion.—A number of interesting points of a general character may be noted, some of which are brought out in the above brief descriptions, while others are well founded on data now being gathered together for publication in greater detail than is possible in an article of this character.*

First. It may safely be said that the Coal Measure strata are in a general way conformable with the upper surface of the Mississippian floor. The almost uniform thickness of the Cherokee shales over such wide areas and the regularity of the succeeding formations indicate this. Nowhere is so great a difference known between the direction of the bedding planes of the Cherokee shales or the Oswego limestone and the floor surface as is to be found in connection with either the Thayer shales or the Lawrence shales, each of which is a wedge-shaped body. The dip of the succeeding strata in general is of the same kind. The Oswego limestone, from Oswego to Independence, a distance of thirty-two miles, dips fully 625 feet, or nearly twenty feet to the mile. The Iola limestone in the southern part of the state dips nearly as much, while from Kansas City to Lawrence and Topeka it dips a little over 10 feet to the mile.

The nonconformity between the Coal Measures and the Mississippian floor is therefore local in character and principally due to surface erosion rather than being widespread and general. Nonconformity has already been pointed out in Kansas, Missouri, and Iowa, but in every instance known to the writer the illustrations have covered but narrow distances, such as those mentioned in Cherokee county, Kansas, St. Louis and Keokuk. Few fields afford such excellent opportunity for studying this phase of stratigraphy as Kansas now does with her scores of deep wells almost all over all the Coal Measure area.

Second. It would seem there can be little question but that the different formations lie one above the other in regular order, similar to the order usually found to obtain in other parts of the geologic column and in other parts of the world. It is exceedingly probable that all of the Cherokee shales were formed before any part of the Oswego limestones, and that

* Vol. i of the University Geological Survey of Kansas.

this in turn is older than any of the shale beds above, a condition which obtains throughout the whole of the Coal Measures, each particular limestone or shale system being older than any and all of the rocks placed above it in our general section (Plate IX) and younger than those placed below.* Every broad fact in the stratigraphy observed during three summers of extended field work by the writer and his assistants imply this. The paleontologic evidence also favors this view. A review of the fauna given shows that there has been a gradual progression from older to more recent forms continuously from the Cherokee shales upwards.

Third. The general character of the shales throughout the whole of the Coal Measures is such that they must have been deposited, in the main, in shallow water, probably ocean water. The great frequency of ripple marks and other physical properties indicate this. The Burlingame shales with their reptilian tracks are at least one hundred and twenty-five miles northwest of the Cherokee shales and geologically about 2200 feet above the base of the Coal Measures. The coastal area must therefore have progressed westward as geologic time advanced.

Fourth. The thickness of the Kansas Coal Measures cannot be much if any less than 2500 feet. In the general section herewith presented (Plate IX) it amounts to 2750 feet, but in it the average thickness of each formation is given as it is known. As some of them, particularly the Thayer, the Lane, and the Lawrence shales, are known to have different thicknesses in different parts of the state, it is presumable that no one point could be found with all the systems as thick as given in the general section. However, at Cherryvale the known thickness from the top of the hills is a little over 1100 feet, while

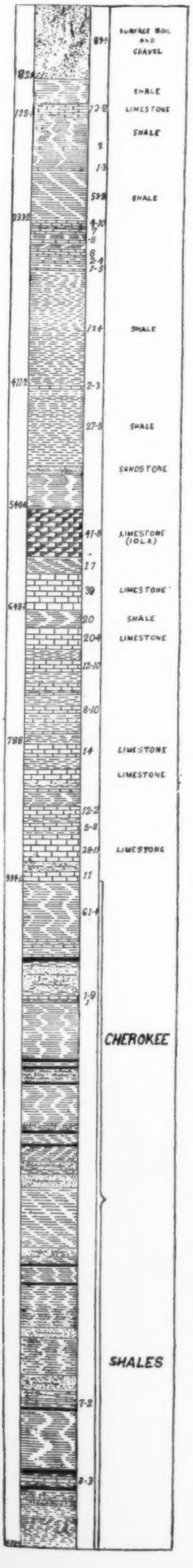
* This statement may seem unnecessary, but those who have carefully followed the writings of Winslow and Keyes on the Coal Measures of Missouri and Iowa will recall that different views have been expressed. See Winslow, Bulletin Am. Geol. Soc., vol. iii, p. 109, and Mo. Geol. Surv. Preliminary Report on Coal, pp. 19–32, Keyes, Ia. Geol. Sur., vol. i, 1892, pp. 84–85: "At the same time it must be remembered that this does not necessarily imply that the 'lower' measures are to be considered much older than the 'upper,' but rather that along the great and successive planes of sedimentation different beds of the upper and lower divisions were laid down contemporaneously;" and vol. ii, p. 160: "Heretofore the general impression has been that the 'Lower' Coal Measures of the state were deposited prior to the laying down of the rocks of the Upper Division. Recent investigation seems to show that the two were formed contemporaneously;" p. 161, "The 'Lower' Coal Measures are not then a series of beds laid down previous to the deposition of the 'Upper' Coal Measures. Each particular part of the former was deposited at the same time as portions of the latter farther seaward. . . As a whole, the 'Lower' Coal Measures do actually lie beneath the 'Upper' Coal Measures; but the line of separation is not a line drawn parallel, but obliquely to the planes of sedimentation." See also figs. 9 and 10, p. 162; Mo. Geol. Surv., vol. iv, p. 80–81; and this Journal, vol. l, pp. 241–242.

the general section gives it but 950; at Kansas City the known thickness from the hill tops is 1000 feet, and that given in the general section is but a little over 1100. At Fall River the known thickness from the valley is 1405 feet, and that given in the section but 1300. At Topeka a hundred and ten miles from the southeast limit the known thickness below the hill tops is 1750 feet with the deep well not having reached the base of the Coal Measures. In the general section the thickness here is 2050 feet. The writer has no doubt but that could a well be drilled in from the top of Buffalo Mound near the Kansas River or from the top of the Flint Hills in the southern part of the state, it would be found that the total thickness of the Coal Measures from the top of the Cottonwood formation would exceed 2500 feet.*

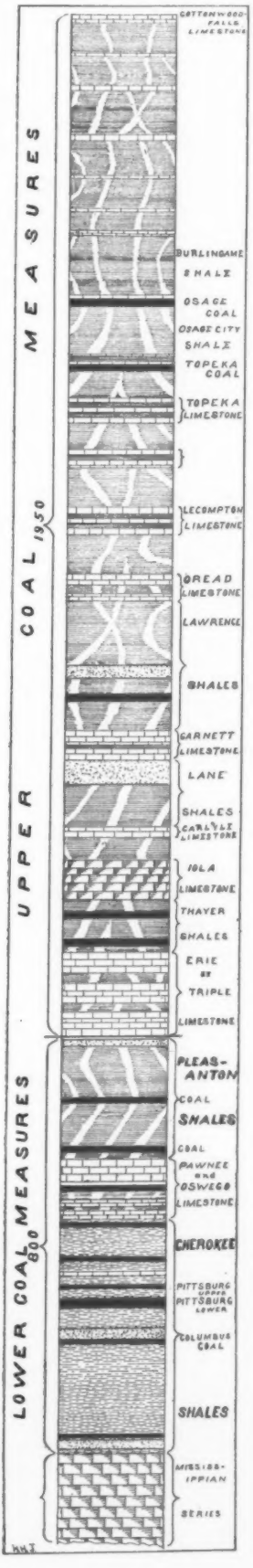
University of Kansas, Lawrence, October 30, 1895.

*See Keyes on thickness of Kansas Coal Measures, this Journal, vol. 1, p. 241, September, 1895.

TOPEKA WELL,
DIAMOND DRILL CORE.
Scale 150 feet = 1 inch.



GENERAL SECTION OF
COAL MEASURES.



Art. LII.—*Igneous Rocks of Yogo Peak, Montana;** by W. H. Weed and L. V. Pirsson.

The two great geographic provinces of Montana, the Plains and the Cordilleran region, which form the eastern and western parts of the State respectively, are quite as sharply delimited as is usually the case along the Rocky Mountain front. In the central part of the State, however, the broad level expanse to which the Cretaceous rocks have been reduced is broken by several mountainous tracts, rising abruptly above the plains and suggesting the Indian designation of "Island Mountains." To the westward the continuous but irregular front of the Rocky Mountain Cordillera stretches in a sinuous, indented line, in a generally northwest and southeast direction.

In the northern part of the State the Rocky Mountains present an abrupt chain of rugged, serrated peaks, which are visible for a hundred miles eastward. To the southward, where the Missouri emerges from the mountains and enters the open plains, the main chain or continental watershed is flanked by the low and broad mountainous area of the Belt ranges, and still farther south, where the waters of the Yellowstone Lake feed the mountain drainage, the front of the Cordillera is composed of several lesser and detached mountain systems.

The Belt Mountains, although a part of the Rocky Mountain Cordillera, constitute an area between the western limits of the Plains and the mountain valley of the Missouri river. This broad and relatively low mountain district is separated by the wide, intermontane valley of Smith river, a tributary of the Missouri, into two ranges, known as the Big Belt and the Little Belt mountains. Yogo Peak, whose rocks form the subject of the present paper, is a conspicuous summit of the Little Belt Mountains, the easternmost of these two ranges.

The Little Belt Mountains thus form a distinct geographic unit in the topography of the State. They are flanked by the valley of the Musselshell river on the south, and extend, from the Judith Gap on the east, westward to their union with the Big Belt Range in the canyon of the Missouri river. They are embraced between the meridians of 109° 45′ and 112° west longitude, and the parallels 45° 30′ and 47° 15′ of latitude.

The Belt ranges together constitute a broad anticlinal uplift formed by the union of the lesser anticlinal axes of the two ranges. The Little Belt uplift has a southeast and northwest trend and dies out in the eastern point of the range at Judith Gap. In the central portion of the mountains the anticlinal uplift is

* By permission of the Director of the U. S. Geological Survey.

broken by profound faults, while the outer flanks of the range show many subsidiary folds further modified by laccolitic and other forms of igneous intrusions. Metamorphic rocks, which belong to the Archean complex of the region, are exposed in the central portion of the range and are covered by a series of sediments known as the Belt Mountain formation, belonging to the Algonquin (or possibly lower Cambrian) age. The overlying Paleozoic series is well developed, characterized by abundant fossil faunas, and includes all the subdivisions thus far recognized in the northern Rocky Mountains. The Mesozoic does not occur within the mountain region, but is everywhere upturned upon the flanks of the range.

The topography of the area is a consequence of its geologic structure. The heavily-bedded Paleozoic limestones, which are nearly horizontal in the central portions of the mountains, form broad and level, pine-clad plateaus whose average elevation is 8,000 feet above the sea and 4,000 feet above the adjacent plains. These plateaus are trenched by the streams whose valleys vary in character with the nature of the rocks, being especially bold and rugged where cut through the massive, heavily-bedded Carboniferous limestones. This is especially noticeable along the course of Belt Creek and in the canyons of the Judith river, the two principal streams which drain the mountains. The former exposes excellent sections along its course, the stream cutting through the Archean area, flowing in a high-walled canyon across the Cambrian rocks and emerging from the mountains through Sluice Box Canyon, a narrow gorge cut in the heavy Carboniferous beds. A branch of the Great Northern railroad, built along the course of the stream, runs to Neihart, a well-known mining town situated near the head of Belt Creek.

While the range as a whole consists of uplifted sedimentary strata, this structure is greatly modified by igneous intrusions in the northern part of the mountains. Several large typical laccolites, only partly stripped of their sedimentary cover, form the dominant peaks of this part of the range, and two centers of igneous intrusion have been found where massive, granular, igneous rocks occur. One of these is found at Barker, a town at the head of the dry fork of Belt Creek; the other at Yogo Peak, the most striking and nearly the highest peak of the mountains.

Yogo Peak.—Yogo Peak is from many points of view the most conspicuous elevation of the Little Belt range. Although not snow-capped, it projects above the timber line, and its sombre crown of crags, formed of massive igneous rock, is in sharp contrast to the rounded summits and level plateaus adjacent. It is situated 8 miles east of Neihart and on the high

divide between the waters of Belt Creek and the Judith river, and reaches an elevation of 9,000 feet above tide. The ridge above which the summit stands has an open and park-like character. The adjacent streams have cut deeply through the horizontal sedimentary rocks, and the broad valley bottom of Dry Wolf Creek on the north and the placer bars of Yogo on the south are 3,000 feet below the crags of the mountain summit. The region about Yogo Peak is formed of Paleozoic rocks in which there are numerous intrusive sheets and occasional dikes of igneous rocks. The mountain mass itself is due to the resistant nature of the massive igneous rock, which forms a stock breaking up through the horizontal sedimentary rocks. The flanks of the mountain show these bedded rocks well exposed and forming benches which mark the more resistant beds. The stock itself is a huge chimney of massive rock that has produced considerable contact metamorphism near its junction with the sedimentary rocks. On the southwest side of the peak an uplifted block of the limestones has been broken off, tilted and injected with a number of intrusive sheets thrust in from the adjacent volcanic neck. The northern slopes are obscured by debris and talus slides which hide the exact contact between the stock and the sedimentary rocks, but on the south face of the mountain a branch of Yogo Creek has cut an amphitheatre, whose massive walls of naked rock rise hundreds of feet above the basin whose deep blue lakelets and perennial snow banks form a pleasing feature of the mountain scenery. The marbleized and altered limestones are here seen in actual contact with the massive rock. In general, the alteration of the sedimentaries adjacent to the stock rock has been accompanied by mineralization, producing ore deposits that have been prospected at a great number of points, although they have thus far proved of too little value to warrant working. The summit of the peak is composed of three knobs or hills, separated by small saddles and grassy Alpine meadows. These summits lie in a nearly east and west line, the two outer knobs being a mile and a half apart. They are covered with projecting crags or piles of debris, with the rock in place below them. To the east the peak ends in a shoulder covered by a heavy mantle of platy slide rock, which extends down to a low saddle separating it from the low mountain ridge which extends eastward to Woodhurst Mountain. The mountain summit shows no evidence of glacial action, and a small moraine in the amphitheatre is the only record of former glaciation. The Yogo Peak core is thus a huge chimney of massive granular rock, having a length of two miles in an east and west direction, and a width of one mile. The study of the region shows that this stock occupies the southwestern and expanded end of a great fracture which

has ruptured the sedimentary series, and extends for 10 miles to the northeast in a somewhat irregular line. This fracture is marked by a series of upbreaks of igneous magmas of various types which form intrusions of varying width, accompanied by laccolitic masses, intruded sheets and numerous dikes. The type of rock immediately adjacent to the Yogo Peak mass is a quartz syenite-porphyry, forming the low saddle northeast of the peak and which is succeeded eastward by a repetition of Yogo Peak rock types. Although this rock comes in actual contact with that of Yogo Peak, the line is hidden by debris and its character cannot be determined.

The rock types whose varying phases are discussed in the present article are from the Yogo Peak mass itself, and as the stock shows a constant variation and gradation in its chemical and mineralogical composition along its east and west axis, three types have been selected to show the variation, the specimens coming from the east, middle and western points of the summit of the peak. For purposes of convenience, these will be designated as types from the east, middle, and west knobs respectively.

Petrography of the Yogo Peak Rocks.

Syenite. East knob rock type.—The rock mass composing the high eastern shoulder of Yogo Peak possesses a platy parting which causes it to split readily and to form piles of debris and talus slopes, above which project the low and much-jointed exposures of the rock in place. The joint blocks are short, stout rhomboids, or heavy plates a foot or so long. They are very hard and tough, ring sonorously under the hammer, and are broken with difficulty, the rock being unaltered and fresh. These characters prevail for the entire Yogo Peak mass.

On a freshly fractured surface the rock appears evenly granular, of moderately fine grain, and is compact in character and with few miarolitic cavities. The color is a medium gray with a strong pinkish tone. The rock is clearly a feldspathic one, and of syenitic aspect. Examined with the lens, it is seen to be chiefly composed of light-colored feldspar, dotted with small, dark, formless spots of green pyroxene or hornblende

The microscope shows the following minerals to be present: apatite, titanite and iron ore, pyroxene, hornblende and biotite, orthoclase, oligoclase and quartz. The apatite and titanite are of the usual characters common to such rocks. The iron ore is not abundant and occurs in small grains of about 1^{mm} in diameter. The pyroxene is a very pale green diopside and is much cracked and broken up. It frequently appears like a bundle of rods. It is rarely alone and generally occurs in

common with a brownish-green hornblende. The two minerals are very frequently found together in stout, ill-shaped crystals from 1 to 2^{mm} long, the pyroxene forming a core, surrounded by the hornblende. In such cases the amount of pyroxene is inversely proportional to that of the hornblende. The appearance and association of these two minerals clearly show that the hornblende is paramorphic after the pyroxene. The latter rarely occurs alone, while the hornblende frequently does so. Biotite is rare and occurs only as occasional brown pleochroic shreds.

Orthoclase is the predominant feldspar, occurring in irregular masses. A much smaller quantity of plagioclase is also present, the optical characters proving it to be oligoclase. It is more idiomorphic than orthoclase and is, indeed, often surrounded by a mantle of the latter mineral. A small amount of interstitial quartz completes the list of minerals.

In structure the rock is hypidiomorphic, but only partly so, as the pyroxene and hornblende are themselves rather ill-formed and irregular, and the tendency is toward an allotriomorphic structure. The average size of grain is about 1^{mm}.

The following analysis shows the chemical composition of this rock. It has been made by Dr. W. F. Hillebrand of the U. S. Geological Survey, a chemist whose skill and painstaking accuracy have been of such vast service to American petrography.

Syenite from Yogo Peak.

SiO_2	61·65
TiO_2	·56
Al_2O_3	15·07
Cr_2O_3	trace
Fe_2O_3	2·03
FeO	2·25
MnO	·09
MgO	3·67
CaO	4·61
BaO	·27
SrO	·10
Na_2O	4·35
K_2O	4·50
Li_2O	trace
H_2O at 110°	·26
H_2O above 110°	·41
P_2O_5	·33
	100·15

The above analysis is that of a syenite with moderately high lime, iron and magnesia for a rock of the syenite group. The

comparatively large amount of soda present cannot be entirely in the oligoclase, and the unstriated feldspar undoubtedly contains the albite molecule to some extent. The barium and strontium are possibly present in the feldspar. The mineral and chemical nature of the rock show it to have a somewhat dioritic tendency.

Yogoite. Middle knob rock type.—West of the eastern knob of Yogo Peak the rock forming the summit of the mountain gradually changes in character until it assumes the type which characterizes the middle knob and which is so well displayed in the crags which form this point. The rock has a parting similar to that of the syenite described above, and is like it in its general characters. On a freshly fractured surface the rock is, however, seen to be of a very much darker gray in color, with a greenish tone, and to be more coarsely crystallized, so that it possesses a mottled appearance, recalling a diorite in its habit. Even at a casual glance the rock is seen to be more basic than the syenite, and the ferro-magnesian minerals appear to make up half the bulk of the rock. The reflection of light from numerous cleavage plates of small biotite crystals is also noticeable.

Microscopically, the minerals are seen to be the same as those in the syenite, but with the following differences: The augite, which was a nearly colorless diopside, is here a clear, light green mineral, quite idiomorphic, and having the usual cleavage and appearance, and containing frequent shreds of biotite and granules of iron ore as inclusions. It is very abundant in rather small, stout crystals, and constitutes, in fact, the main ferro-magnesian component. Paramorphs of augite and hornblende are still seen, but they are rare, and the hornblende has dwindled to a very small amount. Iron ore is more abundant than in the syenite and the grains are larger. Biotite is quite abundant in strongly pleochroic tablets of the usual type. The ratio of the plagioclase to the orthoclase is nearly the same as in the syenite. It is, however, somewhat more basic, approaching andesine. The orthoclase is like that of the syenite, but shows a more marked preference to surround the plagioclase and to appear in broader plates. Quartz is wholly wanting. The two predominating minerals are augite and orthoclase, and the great increase of the former over the latter, as compared with the ratio prevailing in the syenite, is disclosed in the chemical composition, as shown in the following analysis by Dr. Hillebrand:

Analysis of Yogoite.

SiO_2	54·42
TiO_2	·80
Al_2O_3	14·28
Cr_2O_3	trace
Fe_2O_3	3·32
FeO	4·13
MnO	·10
MgO	6·12
CaO	7·72
BaO	·32
SrO	·13
Na_2O	3·44
K_2O	4·22
Li_2O	trace
H_2O at 110°	·22
H_2O above 110°	·38
P_2O_5	·59
	100·19

The features of this analysis are the moderate silica and alumina percentages, with the high amount of iron, lime, magnesia and alkalies. Although the minerals (if not quantitatively expressed) are those of the syenite, its chemical composition removes it very far from any typical syenite. The chemical characteristics are, indeed, those of the lamprophyre group, yet it is a fairly coarse-grained, evenly granular rock, forming a transition phase in the center of a great stock. It is to this type that we have given the name of "*Yogoite*," and the reasons for so doing and its systematic position will be discussed later.

Shonkinite. West knob rock type.—The character of the outcrops occurring on the western end of the peak differs somewhat from those which have been previously described. The rock does not possess the thick, platy parting that prevails to the east, but has an exceedingly massive character, giving rise to bold, heavy crags and castle-like forms, often of curious shapes, which rise abruptly from the small grassy plots lying between them. The rock is exceedingly tough and breaks under the hammer with great difficulty. It has changed gradually in character until here it is as much darker than the Yogoite of the middle knob as the latter is with relation to the syenite. On a fresh fracture the rock is of a very dark stone color, and at first glance recalls many coarse, dark gabbros. On inspection it appears that the quantity of ferro-magnesian minerals is very large, and the eye is caught by the reflection of numerous plates of a dark brownish biotite, which average several millimeters in diameter. With the lens a great

abundance of small augites are also seen in the feldspathic constituent.

Under the microscope the same minerals are present as in those of the two types just noted, but the augite, biotite, and iron ore have greatly increased in amount. The increasing tendency of the orthoclase to surround the plagioclase has here resulted in producing broad plates in which small, stout plagioclase laths lie scattered about unoriented. The plagioclase has become more basic and is now andesine. Its amount, compared with that of the orthoclase, has gradually diminished from the syenite down. The broad areas of orthoclase not only contain the plagioclase, but also the other constituents, in a poikilitic manner. Pseudomorphs after olivine are sometimes seen, with an occasional unaltered remnant of olivine substance still remaining. The augite is darker than in the preceding types, and occasional paramorphoses to hornblende still occur. The biotite is fresh, clear, and strongly pleochroic, at times changing to a clear, dark green variety. Apatite is more abundant and is in larger crystals. The structure is a hypidiomorphic, granitoid one. The analysis by Dr. Hillebrand is as follows:

	Shonkinite of Yogo Peak.		Shonkinite of Square Butte.
SiO_2	48·98		46·73
TiO_2	1·44		·78
Al_2O_3	12·29		10·05
Cr_2O_3	trace		----
Fe_2O_3	2·88		3·53
FeO	5·77		8·20
MnO	·08		·28
MgO	9·19		9·68
CaO	9·65		13·22
BaO	·43		undet.
SrO	·08		undet.
Na_2O	2·22		1·81
K_2O	4·96		3·76
Li_2O	trace		trace
H_2O at 110°	·26	}	1·24
H_2O above 110°	·56	}	
P_2O_5	·98		1·51
Fl	·22	Cl	·18
	99·99		100·97
O=Fl	·08	O=Cl	·04
	99·91		100·91

The consideration of this analysis shows the relatively low silica and alumina and the very high amounts of iron, lime and magnesia. The alkalies are still present in considerable amount,

the potash predominating. The analysis is essentially that of a minette, but recalls also the composition of certain tephrites and leucitites. The rock is, however, a rather coarse, massive, evenly granular, stock form, consisting chiefly of augite and orthoclase with considerable accessory biotite, iron ore, and plagioclase, with a lesser amount of olivine and apatite.

At the west end of Yogo Peak a variation of the above type is found that forms large, irregular masses near the contact, the rock being noticeable for the very large, spongy, biotite crystals which it carries. These biotites are at times 1^{cm} across a cleavage face. They are made up of a number of smaller, nearly similarly oriented individuals mixed in with other constituents. Although the mica is subordinate in amount, it has the appearance of being predominantly present, and the rock appears at first glance to be almost wholly made up of these coarse biotite crystals. Examined in thin section under the microscope, it is seen to be composed of the same minerals as the type last described, but the olivine is fresh, showing little or none of the change into resorption pseudomorphs, and the total amount of iron ore, augite, and biotite is greater. The augite is still the predominating ferro-magnesian mineral. The orthoclase shows a still greater tendency toward the poikilitic structure, occurring in broad plates, enclosing other minerals—that is, filling the interspaces between them in similarly oriented areas. It is noticed also that the biotite occurs at times in this manner with respect to olivine, iron ore, and augite, and hence it is later in formation. Sometimes the olivine is surrounded by orthoclase, an uncommon association of these two minerals. In its period of formation, however, the olivine antedates all the other minerals.

As yet, no analysis has been made of this type, but from a study of the section and its comparison with the foregoing types, and of their analyses with one another, it is clearly evident that the process of differentiation which is under description has advanced somewhat further than in the last analysis, and that this rock would show still lower silica, alumina, and soda, with higher lime, iron and magnesia and considerable potash dominating the soda.

Recently under the name of *Shonkinite** we described a rock type from Square Butte in the Highwood Mountains of Montana, some forty miles to the north of Yogo Peak, where it occurs, as the outer differentiated zone of a laccolite composed chiefly of sodalite syenite.

It is a rather coarse, granular rock composed chiefly of orthoclase and augite with accessory iron ore, apatite and biotite with a very small accessory amount of sodalite and traces of nephe-

* Bull. Geol. Soc. Am., vol. vi, pp. 400–422, 1895.

lite, the appearance of these latter minerals in minute amount being clearly influenced by its association with the sodalite syenite. Its recognition as a distinct rock type is founded on its coarse granular structure and the predominance of the ferro-magnesian minerals over the feldspathic one, orthoclase. For purpose of comparison its analysis is quoted beside that of the type described above.

From what has been said it will be seen that the West Knob type of Yogo agrees very closely with the shonkinite of Square Butte, and this agreement is even more marked in the variation with large micas than in the type analyzed. They agree in structure, mineral composition and chemically. In the hand specimen they have a somewhat different habit, owing to the fact that in the Square Butte type of shonkinite the augite crystals are much larger and more idiomorphic than in that from Yogo Peak, while the actual amount of biotite is somewhat less. Under the microscope they closely resemble each other and both have the broad, poikilitic orthoclase areas and the large skeleton biotites. It gives us pleasure to announce the occurrence of this rock type from a second distinct locality.

Differentiation at Yogo Peak.—From what has already been stated it is evident that at Yogo Peak we have a stock of intruded igneous rock of an oval shape which shows a progressive differentiation along its major axis. The rock mass contains essentially the same minerals throughout, but there is a progressive increase in the ferro-magnesian species toward the western end. This is brought out still more strongly by a comparison of the chief rock-making oxides.

	Syenite.	Yogoite.	Shonkinite.
SiO_2	61·65	54·42	48·98
Al_2O_3	15·07	14·28	12·29
Fe_2O_3	2·03	3·32	2·88
FeO	2·25	4·13	5·77
MgO	3·67	6·12	9·19
CaO	4·61	7·72	9·65
Na_2O	4·35	3·44	2·22
K_2O	4·50	4·22	4·96

Here almost without exception the change is progressive. The silica, alumina and soda diminish; the iron oxides, lime and magnesia increase; the potash remains the same or relatively increases. In this connection it is interesting to observe the conduct of the rarer, less essential oxides, which occur in amounts sufficiently large so that the differences between them are evidently not those which fall within the limits of analytical error.

	Syenite.	Yogoite.	Shonkinite.
TiO_2	·56	·80	1·44
BaO	·27	·32	·43
P_2O_5	·33	·59	·98

The change is of precisely the same character as with the main oxides, there is a progressive increase toward the basic end, the titanium is concentrated in the iron ore and the phosphoric anhydride shows itself in the larger amount of apatite present, while the function of the barium is somewhat uncertain. Instances of intrusive stocks which vary in composition in different parts of the same mass are well known, such as for instance that of Carrock Fell, which has been so ably described by Harker,* where the mass grows steadily more basic toward the margin, or that of Ramnäs mentioned by Brögger,† where the reverse is the case. In his recent important monograph‡ Brögger names a rock series which occurs in one individual mass, and which has been formed by the differentiation of the mass in its final resting place ("laccolitic differentiation"§), a "*Facies suit*" to distinguish it from a series of rocks formed from independent magmatic eruptions which show also a continual progression or gradation in their mineralogical and chemical composition. The series is termed a "*Rock Series*" (*Gesteins serie*) in the latter case. The Yogo Peak mass shows an excellent example of the first class, but it is also to be expected that in many given regions a "facies suit" in one erupted mass will correspond to a "rock series" which may be developed in the region at large.

This may be shown, in part at least, for the Yogo district by taking in addition to the series of analyses of Yogo Peak three others, one of a quartz syenite porphyry constituting an immense uncovered laccolite at Big Baldy Mt., some miles northwest of Yogo, and one of a rather coarse-grained augite minette that forms a thick intrusive sheet a number of miles southwest of Yogo, one of a great series that is genetically connected with it in the Little Belt Mts. series of intrusions. These are taken from very complete analyses by Dr. Hillebrand, but here only the important rock-making oxides are considered. To these is added also the analysis of the shonkinite from Square Butte previously given.

* Quar. Jour. Geol. Soc, vol. l, p. 311, 1894, vol. li, p. 125, 1895.
† Zeitschr. f. Kryst, vol. xvi, page 45, 1889.
‡ Gesteine der Grorudit-Tinguait Serie, p. 179, 1894.
§ Loc. cit, p. 153.

	Quartz syenite porphyry. Big Baldy Mt.	Syenite Yogo.	Yogoite Yogo.	Minette Sheep Creek.	Shonkinite Yogo.	Shonkinite Square Butte.
SiO_2	67·04	61·65	54·42	52·26	48·49	46·73
Al_2O_3	15·25	15·07	14·28	13·96	12·29	10·05
Fe_2O_3	1·69	2·03	3·32	2·76	2·88	3·53
FeO	1·13	2·25	4·13	4·45	5·77	8·20
MgO	1·75	3·67	6·12	8·21	9·91	9·68
CaO	2·17	4·61	7·72	7·06	9·65	13·22
Na_2O	4·09	4·35	3·44	2·80	2·22	1·81
K_2O	5·10	4·50	4·22	3·87	4·96	3·76

The very regular gradation which this series shows is quite remarkable, as may be seen in the above table. There are very few irregularities in it. The variations are all along the same lines as those shown at Yogo Peak itself—the gradual fall of silica, alumina and soda together, with the predominance of potash over soda, may be taken as characteristic of this "petrographical province." From consideration of the analyses and the character of the differentiation that has taken place at Yogo Peak, together with the fact that the coarse mica type of shonkinite shows this differentiation in a higher degree than the type analyzed, it seems probable that it must agree in chemical composition with the Square Butte rock even more closely than the type analyzed does.

Classification of the Yogo rocks.—Here we enter a vexed field. Those who believe in classifying rocks solely by their structure and the *kinds* of minerals they contain without placing any importance upon the *relative quantities* present, or in other words place no stress upon the chemical composition of the magmas from which the rocks are derived, would doubtless call all of the rock varieties at Yogo Peak syenites, since they are composed chiefly of augite and orthoclase.

It seems to us that the time has come when a sharp distinction must be drawn between the use of general terms used by field geologists, such as granite, porphyry, trap, greenstone, etc., and the more exact and definite nomenclature demanded by the needs of petrology. Such general terms have a definite and proper value just as tree, bush and vine have in botany, but the science of petrology demands at present a terminology which will not only be *qualitative* but also *quantitative* in its meanings. While it is neither possible nor desirable to classify rocks on a strictly chemical basis, it is clearly evident that the lines of mineral and consequently of chemical variation must be more strictly drawn than has hitherto been done. This will find its natural manifestation in a more strict regard to the relative quantities of the various minerals which are present and these quantities within reasonable limits must be expressed.*

*See also the discussion of this subject by Brögger (Gest. der Grorudit-Tinguait Serie, p. 91, with whose excellent presentation of the subject we, in the main, heartily agree).

The present work has shown that, starting with the most acid form, we have at Yogo Peak a series of partial magmas with gradually rising lime, iron and magnesia, falling silica, alumina and soda, with potash as the dominant alkali. These crystallized into a series of massive, evenly granular rocks composed chiefly of augite as the ferro-magnesian mineral, but with accessory iron ore, biotite and possibly amphibole and olivine, while the feldspathic component is essentially orthoclase with which may be associated accessory plagioclase. For this series (adding the natural extremes not found at Yogo) we propose the following classification:

All orthoclase, no augite = Sanidinite.
Orthoclase exceeds augite = Augite-syenite.
Orthoclase equals augite = Yogoite.
Augite exceeds orthoclase = Shonkinite
All augite, no orthoclase = Pyroxene and peridotite rocks of various types.

Such a method of classification is a natural one and it does not present hard and fast arbitrary boundaries, but leaves a certain amount of elasticity in the determination of the types. Within certain lines it must also determine the chemical composition. Under the term augite is, of course, included the other accessory ferro-magnesian minerals, as the accessory feldspathic ones are included under the orthoclase.

Summary and Conclusion.—While there are many points of interest connected with the Yogo massif, which in the brief limits of this article have not been touched upon, such as its contact phenomena, the occurrence of aplitic dikes cutting it and its connection with radial dikes and encircling intrusive sheets of various rocks as well as questions of theoretic petrology to which its discussion must give rise, we have endeavored to present the following facts, which will be of general interest.

That Yogo Peak is composed of a core or stock of massive, granular, igneous rock, and that this rock is composed chiefly of augite and orthoclase. That the mass shows a progressive differentiation along its east and west axis, with a continual increase in the ferro-magnesian elements over the feldspathic ones. The resultant rock types have been classified into three groups: syenite, where feldspar exceeds augite; yogoite, where they are practically equal, and shonkinite, where the augite dominates, the latter being similar to a rock type previously described.

Washington and New Haven, October, 1895.

Art. LIII.—*Preliminary Note on a new Alkali Mineral;** by Warren M. Foote.

While searching recently at Borax Lake, California, for the new species sulphohalite,† Mr. C. H. Northup discovered small crystals of what he considered to be a new form of that mineral. Mr. Northup reports that they are very rare, having been found during a laborious working of the "tailings" or debris from an exploratory boring known as the "New Well," made by the Borax Lake Mining Company, and that they were undoubtedly formed in a stratum of clay reached at a depth of about 450 feet.

The entire find was forwarded to Dr. A. E. Foote, to whom the writer is indebted for the material used in this brief examination.

Crystallization, etc.—The mineral crystallizes in regular octahedrons, whose diameter rarely reach one centimeter. They occasionally exhibit triangular markings and a habit of parallel grouping in more or less regular aggregates. Fractured crystals show in the interior a cross of faint lines running perpendicularly to the crystal faces. These are divided by darker planes lying parallel to cubic symmetry, and passing through the angles of the octahedron, dividing it into eight parts. The same thing is noticeable in the clearest of the complete crystals, a bundle of striæ coming from the center of the crystal to the center of each face with the dividing planes clearly visible. This phenomenon is strikingly similar to that observed in cubes of boléite (figured by Bombicci in a memoir on mimetical pyrite, Bologna, 1893). The markings in the present instance are probably due to inclusion of organic matter, as in chiastolite.

The color varies from dirty white, pale yellow and greenish gray to dark brown; the lighter colored crystals closely resemble senarmontite. Cleavage is imperfect. It is brittle and shows uneven fracture. Luster, vitreous on broken surfaces, occasionally bright on crystal planes. Hardness, 3·5 to 4.

Chemical examination.—In powdering the mineral a fetid odor is distinctly perceptible. It is easily fusible before the blowpipe; in the closed tube it blackens and gives off a burnt odor with violent decrepitation and liberation of water (which subsequently proved to be mechanically included), finally fusing to a gray mass. Boiling water effects partial decomposition of the powdered mineral, with separation of a bulky white

* A revision of a paper read before the meeting of the Philadelphia Academy of Natural Sciences, Aug 27th, 1895.

† This Journal, xxxvi, p. 463.

residue, consisting mainly of basic carbonate of magnesia. It is decomposed with effervescence in cold dilute hydrochloric acid, with slight residue insoluble.

A careful qualitative analysis of crystal fragments showed it to consist essentially of sodium, magnesium, hydrochloric and carbonic acids, indicating a *double chloride and carbonate of sodium and magnesium*. Traces of phosphoric acid, silica, iron, calcium and organic matter were also found. This composition is quite as remarkable as that of other species peculiar to the Borax Lake region.

The name "*Northupite*" is proposed for this new species, since it was entirely due to Mr. Northup's indefatigable zeal in collecting that the mineral was brought to light. Professor Penfield has promised to make a quantitative analysis of this and several other interesting minerals found in association, at least one beside the Northupite being new.

ART. LIV. — *Three-toed Dinosaur tracks in the Newark Group at Avondale, N. J.;* by J. B. WOODWORTH.

A "track stratum" appears first to have been recognized in the quarries along the west bank of the Passaic River, in New Jersey, in the Newark rocks, by Mr. Frank L. Nason, of the N. J. Geol. Survey, in 1888. In his description, the general stratigraphic relations of these quarries are set forth, but nothing more is said regarding the tracks other than that they are referred to "reptiles, birds and insects." *

The object of this notice is to confirm Mr. Nason's observations as to the existence of tracks, and to describe a track-covered slab seen in the quarry at Avondale in September of this year. Having come fresh from the collection of dinosaur tracks at Amherst, the writer began a search in the now little-worked Newark quarries. Ill-defined impressions were here seen, but nothing that was satisfactory. At Avondale, markings, due neither to current-mark nor to ripple-mark, were at once seen on the brownish-red shale-covered surfaces of several blocks of freestone. In addition to these equivocal impressions, the following described foot-prints are essentially identical with those found in the Connecticut valley area:

On a triangular block about 7 feet on a side, 15 tracks were seen. These were of two kinds, with the exception of one isolated print, in three lines as follows:

* Annual Report of the State Geologist for 1888, Camden, 1889, pp. 22, 28.

1. Three foot-prints about 8 inches long; stride from toe to toe of 1 and 2 about 19 inches; from toe to toe of 2 and 3, about 31 inches. The tracks resemble the form named *Anomœpus major* by Edw. Hitchcock, the print embracing the impression of the foot together with that of the lower part of the tarso-metatarsus, which latter would make the prolonged, indefinitely-ending, heel-like projection wherever the animal crouched upon the beach.* If this explanation be applicable in this case, the foot proper has a length of about 5 inches.

2. Three-toed prints from 2·5 to 3 inches long, digital impressions jointed; one line of these prints contained five distinct tracks, with a stride of about one foot. The second line of tracks was similar, with six prints.

A heart-shaped impression about four inches on a side and sharply defined was seen on another slab. A similar impression, in the Amherst collection, is in a relation to foot-prints to indicate that it was made by an animal crouching on the beach. Other vague impressions, due to the moulding of the bottom as if by the rolling contact of a flexible, wrinkled body, are probably to be explained as made by dinosaurs in a recumbent position. Long straight and curved furrows also exist both at Avondale and on the track layers in the Newark quarries.

So far as one can judge from tracks, these impressions afford nothing not already known in the Connecticut area. Their existence in the section which has been taken for the type of the Jura-Trias basins along the Atlantic coast, is of importance as serving to remove the criticism which has been made against the revival of Redfield's term,—the Newark group,—that the characteristic fossil tracks of the better known Connecticut area do not occur in it.

I am indebted to my friend, Prof. Geo. C. Sonn, of Newark, N. J., for essaying to have the large slab with fourteen tracks preserved in the High School of that city.

Harvard University, September 18th, 1895.

* I am indebted to Professor Emerson for this explanation of the similar tracks in the collection at Amherst.

ART. LV.—*On the Affinities and Classification of the Dinosaurian Reptiles;** by O. C. MARSH. (With Plate X.)

INTRODUCTION.

FOR several years I have been engaged in the study of the Dinosaurs of North America, and the main results of the investigation have been published both in that country and in Europe. The material for this study consisted of the extensive collections made during my explorations in western North America, especially in the Rocky Mountain region, and the type specimens are nearly all preserved in the museum of Yale University. I first attempted in 1881 to make a classification of the series of specimens thus secured, and in the following year I extended this classification to include the European forms, and again in 1884 I expanded it still further to include all the *Dinosauria* then known.†

Since that time, many new discoveries have been made, and some very strange forms have been brought to light in America, which render a revision of this classification necessary. Besides the American forms, I have studied with care nearly every important specimen of Dinosaurs preserved in the museums of Europe, and as a result of all this investigation, I shall present to you an abstract, bringing the subject down to date. This will include a short statement as to the affinities of the Dinosaurs, so far as I have been able to make them out, and a synopsis of the classification, based mainly upon the characters of the Dinosaurs I have myself examined.

To bring the subject directly before you, I have prepared the chart here shown (Plate X), which gives restorations of the skeletons of the twelve best known Dinosaurs, so far as I have been able to reconstruct them. Of these twelve forms, eight are from America; *Anchisaurus*, a small carnivorous type from the Trias; *Brontosaurus*, *Camptosaurus*, *Laosaurus*, and *Stegosaurus*, all herbivorous, and the carnivorous *Ceratosaurus*, from the Jurassic; with *Claosaurus* and *Triceratops*, herbivores from the Cretaceous. These American forms, with four from Europe, types of the well-known genera *Compsognathus*, *Scelidosaurus*, *Hypsilophodon*, and *Iguanodon*, complete the series represented on this chart. They form together an instructive group of the remarkable Reptiles we are now considering.

* Abstract of paper read before the International Congress of Zoologists, at Leyden, September 17, 1895.

† This Journal, vol. xxi, p. 423, May, 1881; vol. xxiii, p. 81, January, 1882; Report British Association for the Advancement of Science, for 1884, p. 763.

Affinities of Dinosaurs.

The extinct reptiles known as Dinosaurs were for a long time regarded as a peculiar order, having, indeed, certain relations to Birds, but without being closely allied to any of the other groups of known Reptiles. *Megalosaurus* and *Iguanodon*, the first Dinosaurian genera described, were justly considered as representing two distinct families, one including the carnivores, and the other the herbivorous forms.

With the discovery and investigation of *Cetiosaurus* and its allies in Europe, and especially of the gigantic forms with similar characters in America, it became evident that these reptiles could not be placed in the same families with *Megalosaurus*, or *Iguanodon*, but constituted a well-marked group by themselves. It was this new order, the *Sauropoda*, as I have called them, that first showed definite characters allying them with other known groups of Reptiles. In 1878, I pointed out that the *Sauropoda* were the least specialized of the Dinosaurs, and I gave a list of characters in which they showed such an approach to the Mesozoic Crocodiles as to suggest a common ancestry at no very remote period.*

1.

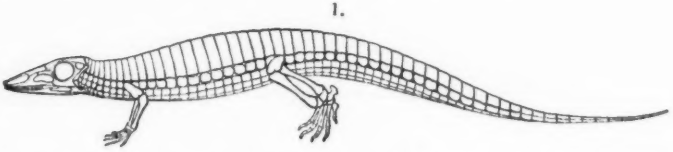


Figure 1.—Restoration of *Aëtosaurus ferratus*, Fraas; with dermal armor of the limbs removed. One-eighth natural size.

Again in 1884, I called attention to the same point, and also to the relationship of Dinosaurs with the *Aëtosauria*, as I had named them, a group of small reptiles from the Triassic of Germany, showing strong affinities with Crocodilians.† A restoration of one of these small animals is shown in the diagram before you (figure 1). In the same communication I compared with Dinosaurs another allied group, the *Hallopoda*, which I had described from the lower Jurassic of America, but had not then fully investigated. Subsequent researches proved the latter group to be of the first importance in estimating the affinities of Dinosaurs, and in another diagram (figures 4–5), I have placed before you restorations of the fore and hind limbs of the type species (*Hallopus victor*).

* This Journal, vol. xvi, p. 412, November, 1878.
† Report British Association, Montreal Meeting, 1884, p. 765.

Another group of extinct Reptiles, which may be termed the *Belodontia*, were considered in the same paper, as allies of the *Dinosauria*. They are known from the Trias of Europe and America, and the type genus *Belodon* has been investigated by many anatomists, who all appear to have regarded it as Crocodilian; an opinion that in the light of our present knowledge may fairly be questioned.

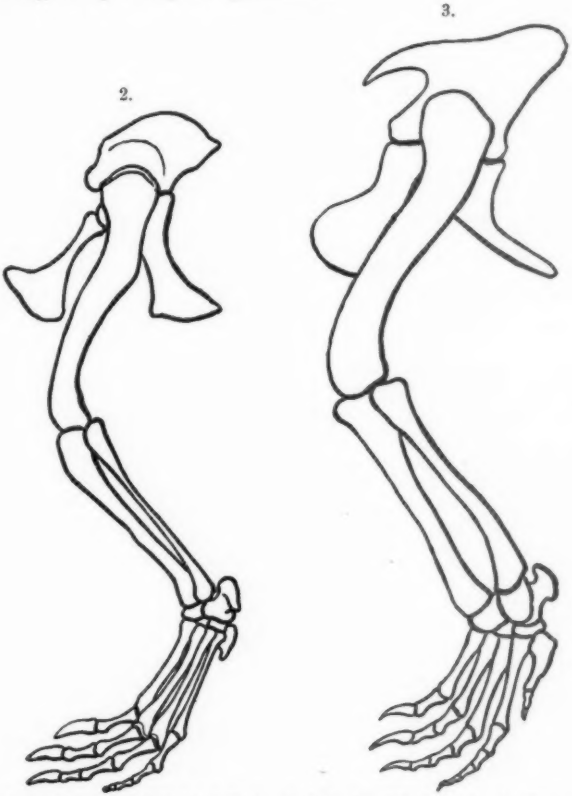


FIGURE 2.—Diagram of left hind limb of *Alligator Mississippiensis*, Gray; seen from the left; in position for comparison with Dinosaurs. One-fourth natural size.

FIGURE 3.—Diagram of left hind limb of *Aëtosaurus ferratus*; in same position. One-half natural size.

The relations of these various groups to the true Crocodiles on the one hand and to Dinosaurs on the other is much too broad a subject to be introduced here, but I may at least call your attention to some points of resemblance between the Dinosaurs and these supposed Crocodilian forms, that seem to indicate genetic affinities.

If we compare some of the characteristic parts of the skeletons of these groups; e. g., of the true *Crocodilia* as existing to-day, the *Belodontia*, the *Aëtosauria*, and the *Hallopoda*, and all with the corresponding portions of the more typical Dinosaurs, the result may indicate in some measure the relationship between them. Taking first the

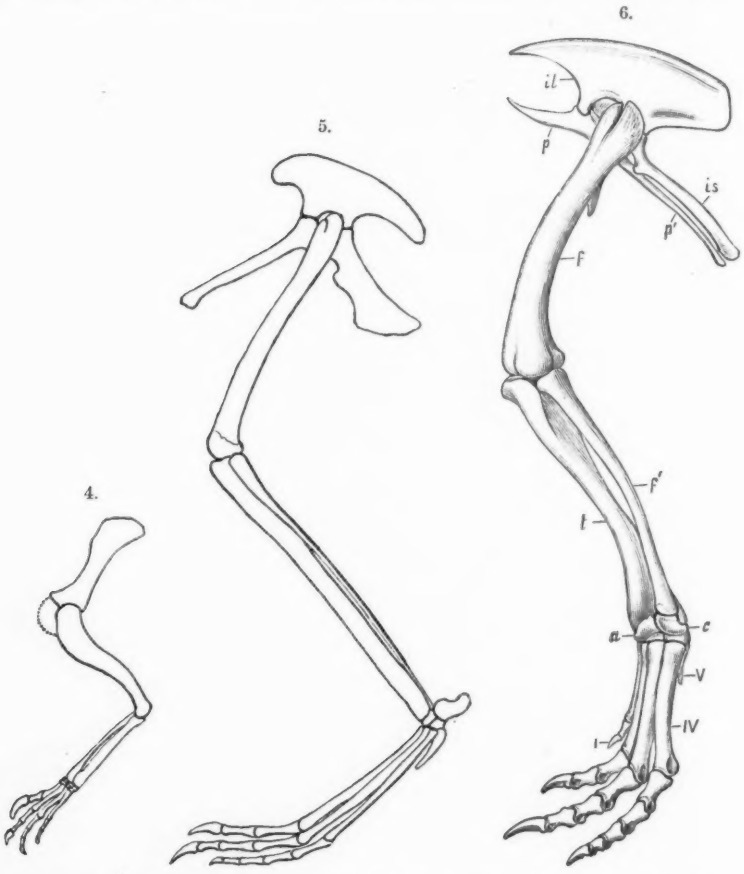


FIGURE 4.—Diagram of left fore limb of *Hallopus victor*, Marsh; seen from the left.

FIGURE 5.—Diagram of left hind limb of same individual. Both figures are one-half natural size.

FIGURE 6.—Left hind leg of *Laosaurus consors*, Marsh; outside view. One-sixth natural size. *a*, astragalus; *c*, calcaneum; *f*, femur; *f'*, fibula; *il*, ilium; *is*, iscnium; *p*, pubis; *p'*, postpubis; *t*, tibia; *I*, *IV*, *V*, first, fourth, and fifth digits.

pelvis and hind limb, as being especially characteristic, we find in the existing *Alligator*, as represented in the diagram (figure 2), that the pubic bone is excluded from the acetabulum, articulating alone with the ischium, and not at all with the ilium. The calcaneum, moreover, has a posterior extension. In *Aëtosaurus*, as shown in the corresponding diagram (figure 3), the pubic bone forms part of the acetabulum, as in Dinosaurs and Birds, and this is a noteworthy difference from all the existing Crocodiles. The hind foot, however, is of the Crocodilian type, with the calcaneum showing a posterior projection.

7.

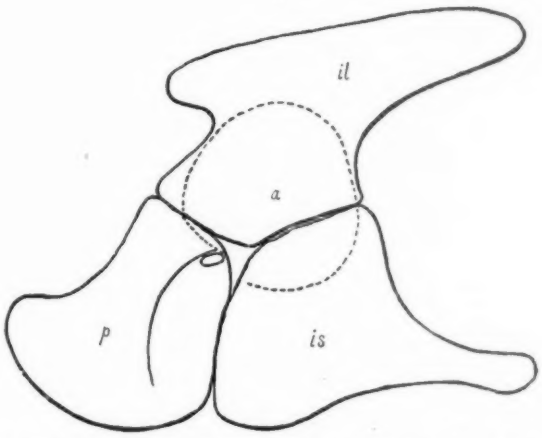


FIGURE 7.—Diagram of pelvis of *Belodon Kapffi*, von Meyer; seen from the left. One-fourth natural size.

a, acetabular surface, within dotted line; *il*, ilium; *is*, ischium; *p*, pubis.

In *Belodon*, the pelvis of which alone is here represented (figure 7), the pubis contributes a very important part to the formation of the acetabulum, and to the entire pelvic arch. The latter differs from the pelvis of a typical Dinosaur mainly in the absence of an open acetabulum, but a moderate enlargement of the fontanelle at the junction of the three pelvic elements would essentially remove this difference. A more erect position of the limb, leading to a more distinct head on the femur, might possibly bring about such a result. The feet and limbs of *Belodon* are Crocodilian in type.

Bearing these facts in mind, the diagram representing the restored fore and hind limbs of the diminutive *Hallopus* (figures 4–5) shows first of all the true Dinosaurian pelvis, with the pubic bone taking part in the open acetabulum, and forming an important and distinctive element of the pelvic arch. The delicate posterior limb and foot, evidently adapted

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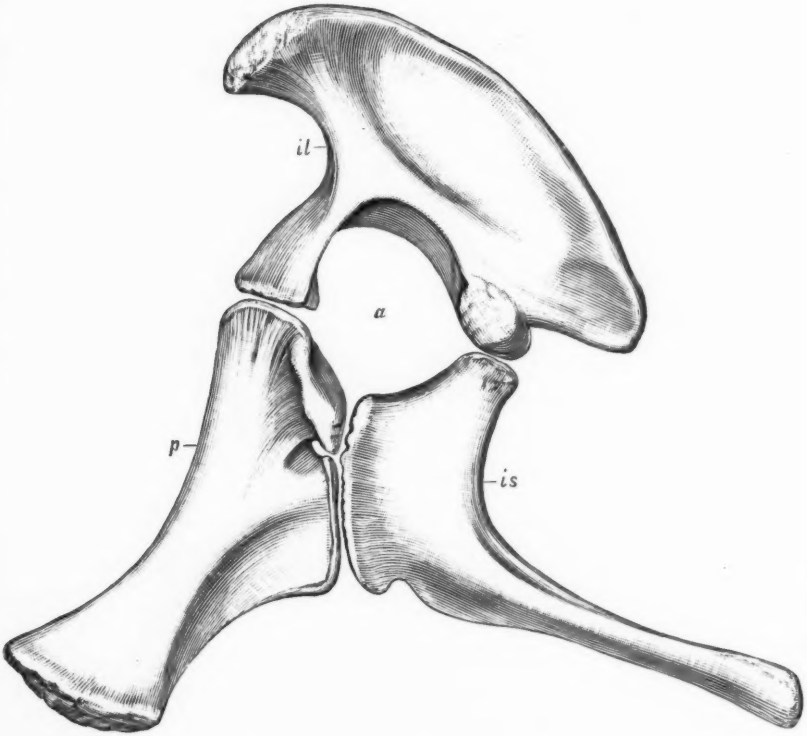

FIGURE 8.—Pelvis of *Morosaurus lentus*, Marsh; seen from the left. One-eighth natural size.

a, acetabular opening; other letters as in figure 7.

mainly for leaping, as the generic name suggests, are quite unique among the *Reptilia*, but the tarsus, especially the calcaneum, recalls strongly the same region in the orders already passed in review.

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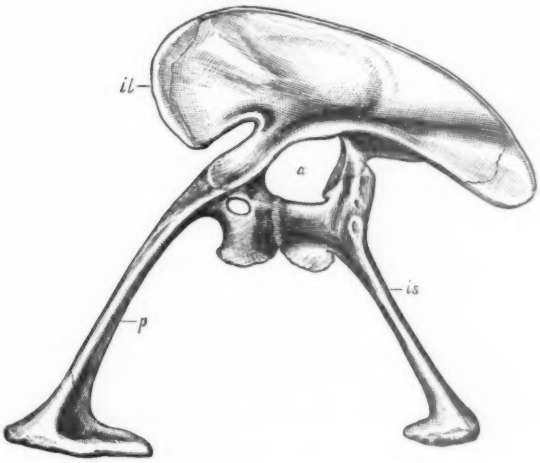

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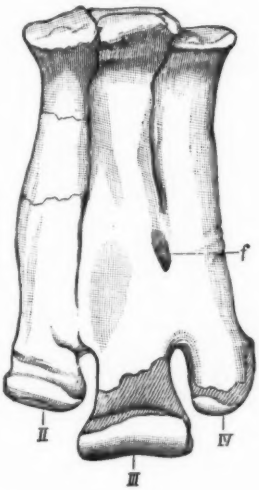

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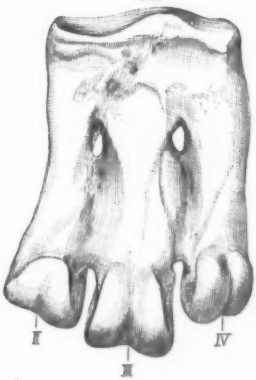


FIGURE 9.—Pelvis of *Ceratosaurus nasicornis*, Marsh; seen from the left. One-twelfth natural size. Letters as in figure 8.

FIGURE 10.—United metatarsal bones of *Ceratosaurus nasicornis*; left foot; front view. One-fourth natural size.

FIGURE 11.—United metatarsal bones of great Penguin (*Aptenodytes Pennantii*, G. R. Gr.); left foot; front view. Natural size.

Just what this posterior extension of the calcaneum signifies in this case, it is difficult to decide on the evidence now known. It may be merely an adaptive character, as *Hallopus* appears in nearly every other respect to be a true carnivorous Dinosaur. It may, however, be an inheritance from a Crocodilian ancestry, and preserved by a peculiar mode of life. Whatever its origin may have been, it was certainly, during the life of the animal, an essential part of the remarkable leaping foot to which it belonged, and in which it has since kept its position undisturbed. The presence of such an element in the foot of this diminutive Dinosaur certainly suggests that the group *Hallopoda*, which I have considered an order, stands somewhat apart from the typical *Theropoda*, but not far enough away to be excluded from the subclass *Dinosauria*, as I have defined it in the present communication.

In the genus *Zanclodon*, which is from essentially the same geological horizon in Germany as *Aëtosaurus* and *Belodon*, we have one of the oldest true Dinosaurs known, and a typical member of the order *Theropoda*. In the pelvic arch of this reptile, the ilium and ischium are in type quite characteristic of the group to which it belongs, but the pubic elements are unique. They consist of a pair of broad, thin plates united together so as to form an apron-like shield in front, quite unlike anything known in other Dinosaurs. The wide pubic bones of *Belodon*, and the corresponding plates in some of the *Sauropoda* (*Morosaurus*, figure 8), indicate that this feature of the reptilian pelvis may have been derived from some common ancestor of a generalized primitive type. The known transformations of this same pelvic element in one other order of Dinosaurs (the *Predentata*) make the modifications here suggested well within the limits of probability. The hind limb of one genus of this order is shown in figure 6.

The skulls of *Aëtosaurus* and *Belodon* both show features characteristic of some of the Dinosaurs, especially of the *Sauropoda*, but these features need not be discussed here.

The relation of Dinosaurs to Birds, a subject of importance, must also be postponed for another occasion. One point, however, may be mentioned in this connection. The pelvic bones of all known Birds, living and extinct, except the genus *Archæopteryx*, are coössified, while in all the known Dinosaurs they are separate, excepting *Ceratosaurus* (figure 9) and *Ornithomimus*. Again, all known adult Birds, living and extinct, with possibly the single exception of *Archæopteryx*, have the tarsal bones firmly united (figure 11), while all the *Dinosauria*, except *Ceratosaurus* (figure 10), have these bones separate. The exception in each case brings the two classes near together at this point, and their close affinity is thus rendered more probable.

These few facts will, I trust, throw some light on the affinities of the Reptiles known as the *Dinosauria*. The problem is certainly one of much difficulty, and I hope soon to discuss it more fully elsewhere.

Classification of Dinosaurs.

In the present review of the Dinosaurs, I have confined myself mainly to the type specimens which I have described, but have included with them other important remains where these were available for investigation. The extensive collections in the museum of Yale University contain so many of the important type specimens now known from America, that they alone furnish an admirable basis for classification, and it was upon these mainly that I first established the present system, which has since been found to hold equally good for the Dinosaurs discovered elsewhere. In the further study of these reptiles, it was also necessary to examine both the European forms and those from other parts of the world, and I have now studied nearly every known specimen of importance. These investigations have enabled me to make this classification more complete, and to bring it down to the present time.

Many attempts have been made to classify the Dinosaurs, the first being that of Hermann von Meyer, in 1830. The name *Dinosauria*, proposed for the group by Owen, in 1839, has been generally accepted, although not without opposition. Hæckel, Cope, and Huxley followed, the last in 1869 proposing the name *Ornithoscelida* for the order, and giving an admirable synopsis of what was then known of these strange Reptiles and their affinities. Since then, Hulke, Seeley, and Lydekker, Gaudry, Dollo, Baur, and many others, have added much to our knowledge of these interesting animals. The remarkable discoveries in North America, however, have changed the whole subject, and in place of fragmentary specimens, many entire skeletons of Dinosaurian reptiles have been brought to light, and thus definite information has replaced uncertainty, and rendered a comprehensive classification for the first time possible.

The system of classification I first proposed in 1881 has been very generally approved, but a few modifications have been suggested by others that will doubtless be adopted. This will hardly be the case with several radical changes recently advocated, based mainly upon certain theories of the origin of Dinosaurs. At present these theories are not supported by a sufficient number of facts to entitle them to the serious consideration of those who have made a careful study of these reptiles, especially the wonderful variety of forms recently made known from America.

Further discoveries may in time solve the problem of the origin of all the Reptiles now called Dinosaurs, but the arguments hitherto advanced against their being a natural group are far from conclusive. The idea that the *Dinosauria* belong to two or more distinct groups, each of independent origin, can at present claim equal probability only with a similar suggestion recently made in regard to mammals. This subject of the origin of the Dinosaurs and the relation of their divisions to each other will be more fully treated by me elsewhere.

A classification of any series of extinct animals is of necessity, as I have previously said, merely a temporary convenience, like the book shelves in a library, for the arrangement of present knowledge. In view of this fact and of the very limited information we now have in regard to so many Dinosaurs known only from fragmentary remains, it will suffice for the present, or until further evidence is forthcoming, to still consider the *Dinosauria* as a subclass of the great group of *Reptilia*.

Regarding, then, the Dinosaurs as a subclass of the *Reptilia*, the forms best known at present may be classified as follows:

Subclass DINOSAURIA, Owen.

Premaxillary bones separate; upper and lower temporal arches; no teeth on palate; rami of lower jaw united in front by cartilage only. Neural arches of vertebræ joined to centra by suture; sacral vertebræ united. Chevrons articulated intervertebrally. Cervical and thoracic ribs double-headed. Clavicles wanting. Ilium prolonged in front of the acetabulum; acetabulum formed in part by pubis; ischia meet distally on median line. Fore and hind limbs present, the latter ambulatory, and larger than those in front. Head of femur at right angles to condyles; tibia with procnemial crest; fibula complete; first row of tarsals composed of astragalus and calcaneum only, which together form the upper portion of ankle joint; reduction in number of digits begins with the fifth.

Order THEROPODA (Beast foot). Carnivorous.

Skull with external narial openings lateral; large antorbital vacuity; brain case incompletely ossified; no pineal foramen. Premaxillaries with teeth; no predentary bone; dentary without coronoid process; teeth with smooth compressed crowns, and crenulated edges. Vertebræ more or less cavernous; posterior trunk vertebræ united by diplosphenal articulation.

Each sacral rib supported by two vertebræ; diapophyses distinct from sacral ribs. Sternum unossified. Pubes projecting downward, and united distally. Fore limbs small; limb bones hollow; feet digitigrade; digits with prehensile claws; locomotion mainly bipedal.

(1) Family *Megalosauridæ*. Lower jaws with teeth in front. Anterior vertebræ convexo-concave; remaining vertebræ biconcave; five sacral vertebræ. Ilium expanded in front of acetabulum; pubes slender. Femur longer than tibia. Astragalus with ascending process. Five digits in manus and four in pes.

Genus *Megalosaurus* (*Poikilopleuron*). Jurassic and Cretaceous. Known forms European.

(2) Family *Dryptosauridæ*. Lower jaws with teeth in front. Cervical vertebræ opisthocœlian; remaining vertebræ biconcave; sacral vertebræ less than five; ilium expanded in front of acetabulum; distal ends of pubes coössified and much expanded; an interpubic bone. Femur longer than tibia; astragalus with ascending process. Fore limbs very small, with compressed prehensile claws.

Genera *Dryptosaurus* (*Lælaps*), *Allosaurus*, *Cœlosaurus*, *Creosaurus*. Jurassic and Cretaceous. All from North America.

(3) Family *Labrosauridæ*. Lower jaws edentulous in front. Cervical and dorsal vertebræ convexo-concave; centra cavernous or hollow. Pubes slender, with anterior margins united; an interpubic bone. Femur longer than tibia; astragalus with ascending process.

Genus *Labrosaurus*. Jurassic, North America.

(4) Family *Plateosauridæ* (*Zanclodontidæ*). Vertebræ biconcave; two sacral vertebræ. Ilium expanded behind acetabulum; pubes broad, elongate plates, with anterior margins united; no interpubic bone. Femur longer than tibia; astragalus without ascending process. Five digits in manus and pes.

Genera *Plateosaurus* (*Zanclodon*), *?Teratosaurus*, *Dimodosaurus*. Triassic. Known forms European.

(5) Family *Anchisauridæ*. Skull light in structure, with recurved, cutting teeth. Vertebræ biconcave. Bones hollow. Ilium expanded behind acetabulum; pubes rod-like and not coössified distally; no interpubic bone. Fore limbs well developed. Femur longer than tibia. Five digits in manus and four in pes. (See Plate X, figure 1.)

Genera *Anchisaurus* (*Megadactylus*), *Ammosaurus*, *?Arctosaurus*, *Bathygnathus*, and *Clepsysaurus*, in North America; and in Europe, *Palæosaurus*, *Thecodontosaurus*. All known forms Triassic.

Suborder CŒLURIA (Hollow tail).

(6) Family *Cœluridæ*. Teeth much compressed. Vertebræ and bones of skeleton very hollow or pneumatic; anterior cervical vertebræ convexo-concave; remaining vertebræ biconcave; cervical ribs coössified with vertebræ; an interpubic bone. Femur shorter than tibia. Metatarsals very long and slender.

Genera *Cœlurus*, in North America; and *Aristosuchus*, in Europe. Jurassic.

Suborder COMPSOGNATHA.

(7) Family *Compsognathidæ*. Skull elongate, with slender jaws and pointed teeth. Cervical vertebræ convexo-concave; remaining vertebræ biconcave. Bones very hollow. Femur shorter than tibia. Ischia with long symphysis on median line. Three functional digits in manus and pes.

Genus *Compsognathus*. Jurassic. Only known specimen European. (Plate X, figure 3.)

Suborder CERATOSAURIA (Horned saurians).

(8) Family *Ceratosauridæ*. Horn on skull. Cervical vertebræ plano-concave; remaining vertebræ biconcave. Pelvic bones coössified; ilium expanded in front of acetabulum; pubes slender; an interpubic bone. Limb bones hollow. Manus with four digits. Femur longer than tibia; astragalus with ascending process; metatarsals coössified; three digits only in pes. Osseous dermal plates. (Plate X, figure 5.)

Genus *Ceratosaurus*. Jurassic, North America.

(9) Family *Ornithomimidæ*. Pelvic bones coössified with each other and with sacrum; ilium expanded in front of acetabulum. Limb bones very hollow. Fore limbs very small; digits with very long, pointed claws. Hind limbs of true avian type; feet digitigrade and unguiculate.

Genus *Ornithomimus*. Cretaceous, North America.

Suborder HALLOPODA (Leaping foot).

(10) Family *Hallopidæ*. Vertebræ and limb bones hollow; vertebræ biconcave; two vertebræ in sacrum; acetabulum formed by ilium, pubis, and ischium; pubes rod-like, projecting downward, but not coössified distally; no postpubis; ischia with distal ends expanded, meeting below on median line. Fore limbs very small, with four digits in manus. Femur shorter than tibia; hind limbs very long, with three digits only in pes, and metatarsals greatly elongated; astragalus without ascending process; calcaneum much produced backward; feet digitigrade, unguiculate.

Genus *Hallopus*. Jurassic, North America.

Order SAUROPODA (Lizard foot). Herbivorous.

External nares at apex of skull; premaxillary bones with teeth; teeth with rugose crowns more or less spoon-shaped; large antorbital openings; no pineal foramen; alisphenoid bones; brain case ossified; no columellæ; postoccipital bones; no predentary bone; dentary without coronoid process. Cervical ribs coössified with vertebræ; anterior vertebræ opisthocœlian, with neural spines bifid; posterior trunk vertebræ united by diplosphenal articulation; presacral vertebræ hollow; each sacral vertebra supports its own transverse process, or sacral rib; no diapophyses on sacral vertebræ; neural cavity much expanded in sacrum. Sternal bones parial. Ilium expanded in front of acetabulum; pubes projecting in front, and united distally by cartilage; no postpubis. Limb bones solid; fore and hind limbs nearly equal; metacarpals longer than metatarsals; femur longer than tibia; feet plantigrade, ungulate; five digits in manus and pes; second row of carpal and tarsal bones unossified. Locomotion quadrupedal.

(1) Family *Atlantosauridæ*. A pituitary canal; large fossa for nasal gland. Distal end of scapula not expanded. Sacrum hollow; ischia directed downward, with expanded extremities meeting on median line. Anterior caudal vertebræ with lateral cavities; remaining caudals solid.

Genera *Atlantosaurus*, *Apatosaurus*, *Barosaurus*, *Brontosaurus*. Include the largest known land animals. Jurassic, North America. (Plate X, figure 2.)

(2) Family *Diplodocidæ*. External nares superior; no depression for nasal gland; two antorbital openings; large pituitary fossa; dentition weak, and in front of jaws only; brain inclined backward; dentary bone narrow in front. Ischia with shaft not expanded distally, directed downward and backward, with sides meeting on median line. Sacrum hollow. Caudal vertebræ deeply excavated below; chevrons with both anterior and posterior branches.

Genus *Diplodocus*. Jurassic, North America.

(3) Family *Morosauridæ*. External nares lateral; large fossa for nasal gland; small pituitary fossa; dentary bone massive in front. Shaft of scapula expanded at distal end. Sacral vertebræ nearly solid; ischia slender, with twisted shaft directed backward, and sides meeting on median line. Anterior caudals solid.

Genera *Morosaurus*, *?Camarasaurus* (*Amphicœlias*). Jurassic, North America.

(4) Family *Pleurocœlidæ*. Dentition weak; teeth resembling those of *Diplodocus*. Cervical vertebræ elongated; centrum hollow, with large lateral openings; sacral vertebræ solid, with lateral depressions in centra; caudal vertebræ solid; anterior caudals with flat articular faces, and transversely compressed neural spines; middle caudal vertebræ with neural arch on front half of centrum. Ischia with compressed distal ends, meeting on median line.

Genus *Pleurocœlus*. ? Jurassic, North America.

(5) Family *Titanosauridæ*. Fore limbs elongate; coracoid quadrilateral. Presacral vertebræ opisthocœlian; first caudal vertebra biconvex; remaining caudals procœlian; chevrons open above.

Genera *Titanosaurus* and *Argyrosaurus*. ? Cretaceous, India and Patagonia.

European forms of the order *Sauropoda* are *Bothriospondylus*, *Cardiodon* (*Cetiosaurus*), *Chondrosteosaurus*, *Eucamerotus*, *Ornithopsis*, and *Pelorosaurus*. All probably Jurassic.*

Order Predentata. Herbivorous.

Narial opening lateral; no antorbital foramen; brain case ossified; supra-orbital bones; teeth with sculptured crowns; maxillary teeth with crowns grooved on outside; lower teeth with grooves on inside of crown; a predentary bone; dentary with coronoid process. Cervical ribs articulating with vertebræ; each sacral rib supported by two vertebræ. Ilium elongated in front of acetabulum; prepubic bones free in front; postpubic bones present; ischia slender, directed backward, with distal ends meeting side to side. Astragalus without ascending process.

Suborder Stegosauria (Plated lizard).

No teeth in premaxillaries; teeth with distinct compressed crowns, and serrated edges. Fore limbs small; locomotion mainly quadrupedal. Vertebræ and limb bones solid. Pubes projecting free in front; postpubis present. Femur longer than tibia. Feet plantigrade, ungulate; five digits in manus and four in pes; second row of carpals unossified. Osseous dermal armor.

(1) Family *Stegosauridæ*. Vertebræ biconcave. Neural canal in sacrum expanded into large chamber; ischia directed backward, with sides meeting on median line. Dorsal ribs T-shaped in cross section. Astragalus coössified with tibia; metapodials very short. Five digits in manus; three functional digits in pes. (Plate X, figure 8.)

* The Wealden is here regarded as upper Jurassic, and not Cretaceous. See this Journal, vol. l, p. 412, November, 1895.

Genera *Stegosaurus* (*Hypsirhophus*), *Diracodon*, *?Dystrophæus*, *Palæoscincus*, *Priconodon*, all from North America; and in Europe *Omosaurus*, Owen. Jurassic and Cretaceous.

(2) Family *Scelidosauridæ*. Astragalus not coössified with tibia; metatarsals elongated; three functional digits in pes.

Genera *Scelidosaurus*, *Acanthopholis*, *Hylæosaurus*, *Polacanthus*. Jurassic and Cretaceous. Known forms all European. (Plate X, figure 6.)

(3) Family *Nodosauridæ*. Heavy dermal armor. Bones solid. Fore limbs large; feet ungulate.

Genus *Nodosaurus*. Cretaceous, North America.

Suborder CERATOPSIA (Horned face).

(4) Family *Ceratopsidæ*. Premaxillaries edentulous; teeth with two distinct roots; skull surmounted by massive horn-cores; a rostral bone, forming a sharp, cutting beak; expanded parietal crest, with marginal armature; ? a pineal foramen. Vertebræ solid; anterior cervical vertebræ coössified with each other; posterior dorsal vertebræ supporting on the diapophysis both the head and tubercle of the rib; lumbar vertebræ wanting; sacral vertebræ with both diapophyses and ribs. Pubes projecting in front, with distal end expanded; postpubic bone rudimentary or wanting. Limb bones solid; fore limbs large; femur longer than tibia; feet ungulate; locomotion quadrupedal.

Genera *Ceratops*, *Agathaumas*, *Monoclonius*, *Polyonax*, *Sterrholophus*, *Torosaurus*, *Triceratops*, in North America; and in Europe *Struthiosaurus* (*Cratæomus*). All are Cretaceous. (Plate X, figure 10.)

Suborder ORNITHOPODA (Bird foot).

Premaxillaries edentulous in front. Vertebræ solid. Fore limbs small. Pubes projecting free in front; postpubis present. Feet digitigrade: three to five functional digits in manus and three to four in pes; locomotion mainly bipedal.

(5) Family *Camptosauridæ* (*Camptonotidæ*). Premaxillaries edentulous; teeth in single row; a supra-orbital fossa. Anterior vertebræ opisthocœlian; sacral vertebræ with peg and notch articulation. Limb bones hollow; fore limbs small. Postpubis reaching to the distal end of ischium. Femur longer than tibia, and with pendent fourth trochanter; hind feet with four digits. (Plate X, figure 7.)

Genus *Camptosaurus* (*Camptonotus*). Jurassic, North America.

(6) Family *Laosauridæ*. Premaxillaries edentulous; teeth in single row. Anterior vertebræ with plane articular faces; sacral vertebræ coössified. Sternum unossified. Limb and

foot bones hollow; fore limbs very small; five digits in manus; femur shorter than tibia; metatarsals elongate; four digits in pes.

Genera *Laosaurus* and *Dryosaurus*. Jurassic, North America. (Plate X, figure 4.)

(7) Family *Hypsilophodontidæ*. Premaxillaries with teeth; teeth in single row. Anterior vertebræ opisthocœlian; sacral vertebræ coössified. Sternum ossified. Limb bones hollow; five digits in manus; femur shorter than tibia; hind feet with four digits.

Genus *Hypsilophodon*. Wealden, England. (Plate X, figure 9.)

(8) Family *Iguanodontidæ*. Premaxillaries edentulous; teeth in single row. Anterior vertebræ opisthocœlian. Sternal bones ossified. Postpubis incomplete. (Plate X, figure 11.)

Genera *Iguanodon*, *Vectisaurus*. Jurassic and Cretaceous. Known forms all European.

(9) Family *Trachodontidæ* (*Hadrosauridæ*). Premaxillaries edentulous; teeth in several rows, forming with use a tessellated grinding surface. Cervical vertebræ opisthocœlian. Limb bones hollow; fore limbs small. Femur longer than tibia.

Genera *Trachodon* (*Hadrosaurus*, *Diclonius*), *Cionodon*. Cretaceous, North America.

(10) Family *Claosauridæ*. Premaxillaries edentulous; teeth in several rows, but a single row only in use. Cervical vertebræ opisthocœlian. Limb bones solid; fore limbs small. Sternal bones parial. Postpubis incomplete. Feet ungulate; three functional digits in manus and pes. (Plate X, figure 12.)

Genus *Claosaurus*. Cretaceous, North America.

(11) Family *Nanosauridæ*. Teeth compressed and pointed, and in a single, uniform row. Cervical and dorsal vertebræ short and biconcave. Limb bones and others very hollow; fore limbs of moderate size. Sacral vertebræ three; ilium with very short pointed front, and narrow posterior end. Femur curved, and shorter than tibia; fibula pointed below; metatarsals very long and slender. Anterior caudals short.

Genus *Nanosaurus*. Jurassic, North America. Includes the smallest known Dinosaurs.

EXPLANATION OF PLATE X.

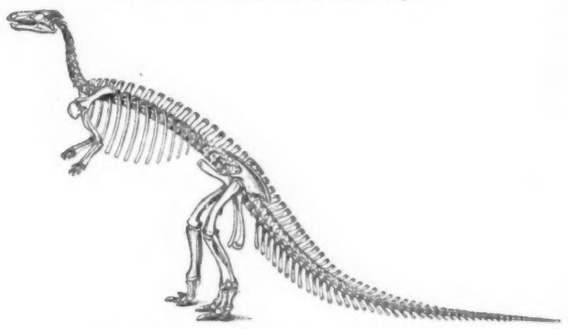
Restorations of Dinosaurian Reptiles.

In this plate, the scientific name, the size, geological formation, and country where found, are given under each of the twelve figures. The skeletons here restored are represented in the same general position, to aid in comparing them with each other.

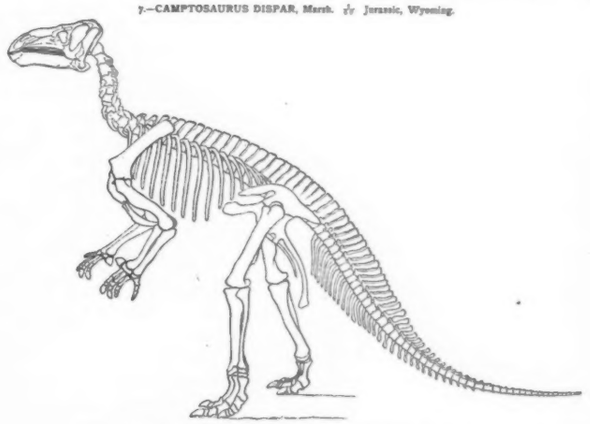
This plate is a reduced copy of the chart shown at Leyden, when the present paper was read. The same chart was also shown at the meeting of the British Association, Ipswich, September 14, 1895.

1.—ANCHISAURUS COLURUS, Marsh. $\frac{1}{24}$ Triassic, Connecticut.

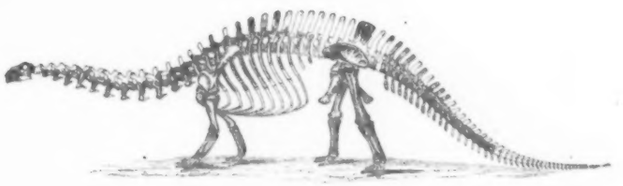
9.—HYPSILOPHODON POXII, Huxley. $\frac{1}{12}$ Cretaceous, England.



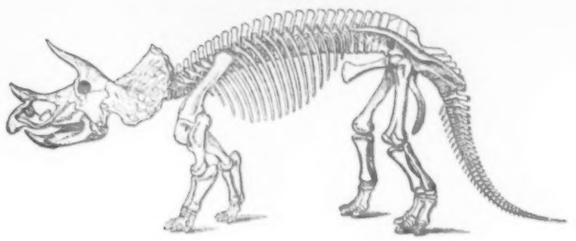
7.—CAMPTOSAURUS DISPAR, Marsh. $\frac{1}{72}$ Jurassic, Wyoming.



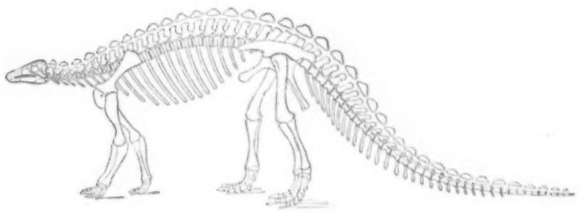
11.—IGUANODON BERNISSARTENSIS, Boulenger. $\frac{1}{72}$ Cretaceous, Belgium.



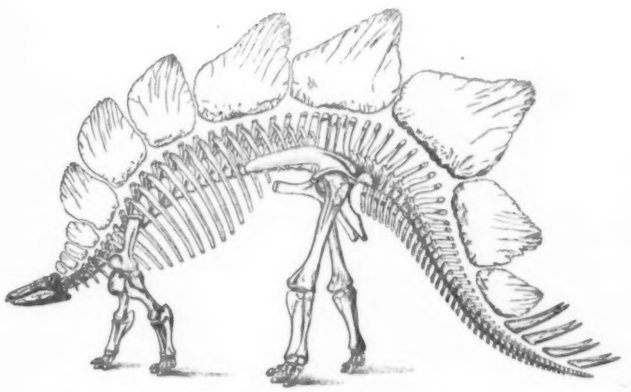
3.—BRONTOSAURUS EXCELSUS, Marsh. $\frac{1}{72}$ Jurassic, Wyoming.



10.—TRICERATOPS PRORSUS, Marsh. $\frac{1}{72}$ Cretaceous, Wyoming.

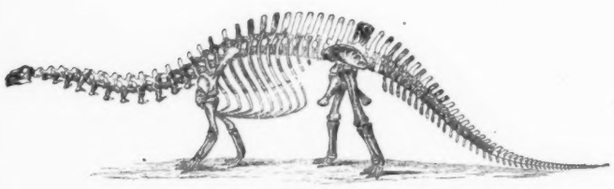


6.—SCELIDOSAURUS HARRISONII, Owen. $\frac{1}{72}$ Jurassic, England.

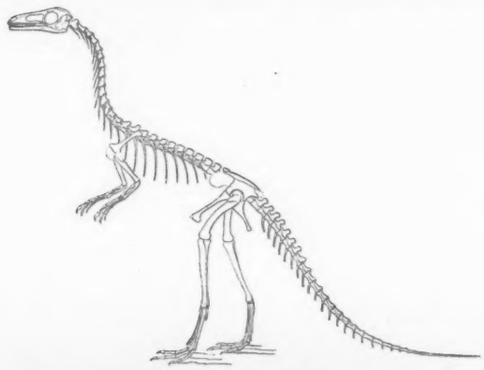


8.—STEGOSAURUS UNGULATUS, Marsh. $\frac{1}{72}$ Jurassic, Wyoming.

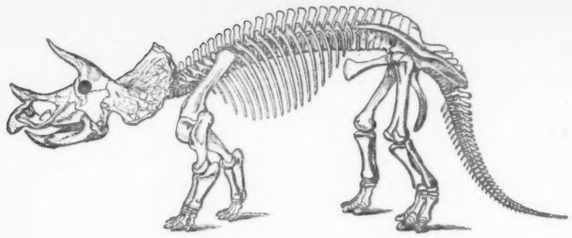
RESTORATIONS OF DINOSAURIAN REPTILES; BY O. C. MARSH.



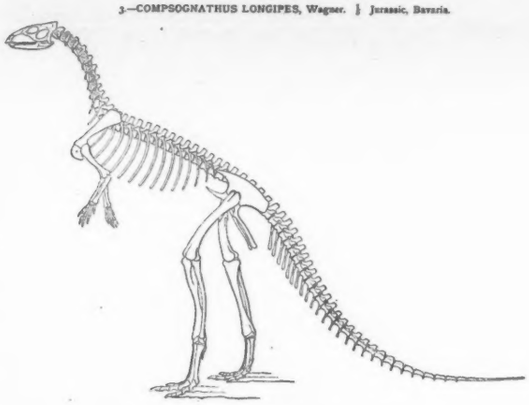
2.—BRONTOSAURUS EXCELSUS, Marsh. $\frac{1}{120}$ Jurassic, Wyoming.



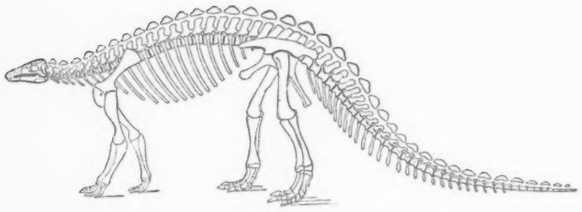
3.—COMPSOGNATHUS LONGIPES, Wagner. $\frac{1}{3}$ Jurassic, Bavaria.



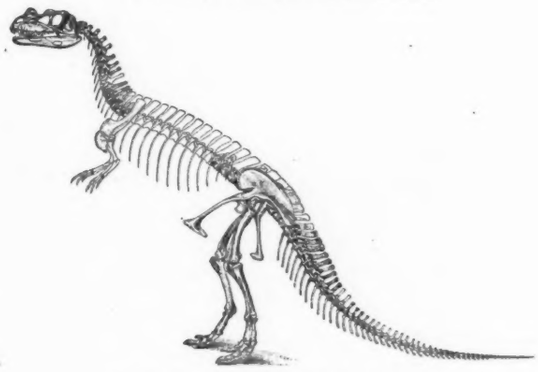
10.—TRICERATOPS PRORSUS, Marsh. $\frac{1}{75}$ Cretaceous, Wyoming.



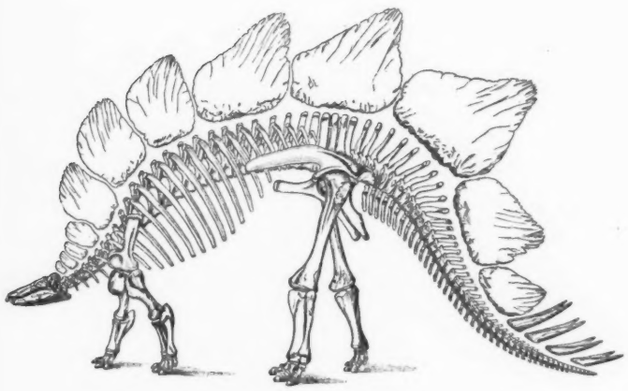
4.—LAOSAURUS CONSORS, Marsh. $\frac{1}{15}$ Jurassic, Wyoming.



6.—SCELIDOSAURUS HARRISONII, Owen. $\frac{1}{15}$ Jurassic, England.



5.—CERATOSAURUS NASICORNIS, Marsh. $\frac{1}{15}$ Jurassic, Colorado.



8.—STEGOSAURUS UNGULATUS, Marsh. $\frac{1}{15}$ Jurassic, Wyoming.

12.—CLAOSAURUS ANNECTENS, Marsh. $\frac{1}{15}$ Cretaceous, Wyoming.

RESTORATIONS OF DINOSAURIAN REPTILES; BY O. C. MARSH.

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SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *A Method for completely dehydrating Alcohol* is recommended by H. Wislicenus and L. Kaufmann, which seems very convenient and practical, and which will probably fill a long-felt want in the laboratory. The reagent used is amalgamated aluminium, which can be prepared in a few moments by treating aluminium filings, free from oil, with caustic soda solution until a brisk evolution of hydrogen is produced, then washing once superficially with water and allowing a $\frac{1}{2}$ per cent solution of corrosive sublimate to act for one or two minutes upon the metal, which is still moist with weak alkali solution. The whole operation is rapidly repeated to remove a black scum which forms, and the product is quickly and thoroughly washed with water, alcohol and ether in succession, and is preserved, if necessary, under low-boiling petroleum-ether. Aluminium filings are on the market, at least in Germany, at a reasonable price. The amalgamation of this metal changes its chemical properties in a remarkable manner, so that it decomposes water violently, and it even becomes hot spontaneously from the action of the moisture of the air, with formation of white flakes of aluminium hydroxide. The reagent has no action upon alcohol and ether, but it reacts promptly with any water contained in them. The authors especially recommend the substance for use in organic chemistry as an entirely neutral reducing-agent.—*Berichte deutsch. chem. Ges.*, xxviii, 1323, June, 1895. H. L. W.

2. *Carbon in Meteoric Irons.*—The well-known finding of diamonds in the Cañon Diablo meteorite has led Moissan to examine several other holosiderites. Five irons, from Texas, Scotland, Chili, Mexico and Russia were studied, but in no case were diamonds found. The author concludes from this investigation that in some metallic meteorites there is no carbon, in others carbon exists either in an amorphous condition or mixed with graphite, and finally, that up to the present time the Cañon Diablo meteorite is the only one known which contains three forms of carbon, viz., black and transparent diamond, graphite and amorphous carbon.—*Compt. Rend.*, cxxxi, 483. H. L. W.

3. *A Study of Amorphous Boron.*—Moissan has investigated the nature of this substance, as prepared by reduction with an alkali-metal according to previously described methods, and finds that such products are very impure. He has succeeded, however, in preparing almost absolutely pure amorphous boron by igniting an excess of anhydrous boracic acid with magnesium powder in a crucible by means of a gas-furnace, then treating the product with acids and igniting it with more boracic anhydride, to remove some remaining magnesium boride, and washing the final product with acids. Special precautions were taken to exclude atmospheric

nitrogen, which combines with boron at high temperatures, forming the nitride. The pure amorphous boron is a powder of a light chestnut color having a density of 2·45. Its electrical conductivity is very weak, and it does not fuse at the temperature furnished by the electric arc. This observation on the infusibility of boron places this element beside carbon as an infusible substance, whereas previous observations, made with impure material, had indicated that it fused in the electric arc. The substance combines more readily with non-metals than with metals. Sodium and potassium can be distilled in contact with it without action, It burns in the air and especially in oxygen with great brilliancy. and it combines with sulphur with incandescence. It has an especially great affinity for oxygen, forming an explosive mixture with lead peroxide, and producing an active gun-powder when mixed, in place of charcoal, with sulphur and potassium nitrate. It reduces sodium carbonate with incandescence at a low red heat, potassium carbonate is reduced at a higher temperature, while calcium and barium carbonates are not reduced. It has a greater affinity for oxygen than have carbon and silicon, for it reduces the oxides of these elements at high temperatures. The powder reduces cold potassium permanganate and ferric solutions, and, by warming, it precipitates silver in a crystalline condition from silver nitrate solutions.—*Ann. Chim. Phys.*, VII, iv, Oct., 1895. H. L. W.

4. *The preparation of Tin Tetrachloride and Tetrabromide.*—The handbooks of chemistry recommend the preparation of these substances by the action of the halogens upon molten tin, but LORENZ finds that no artificial heating is necessary, and in fact, that the action is most favorable near the ordinary temperature. For the preparation of tin tetrabromide the author places solid pieces of tin in a distilling-flask and allows liquid bromine to drop upon them from a capillary opening at the end of a separatory funnel. The addition of the bromine is so regulated that the temperature of the flask is kept between 35° and 59° C. The liquid tetrabromide collects at the bottom of the flask. The product is finally distilled from the same flask in the presence of some remaining metallic tin, giving a perfectly pure, white product. For the production of the tetrachloride in large quantity a glass tube closed at the bottom, like a large test-tube, 30 or 40 inches long and 2 or 2½ inches wide, is provided with a stopper having two holes, through one of which a chlorine delivery tube extends to near the bottom of the large tube. Through the other hole, for a short distance, extends the end of an upright condenser for preventing the loss of the product towards the end of the operation. The large tube is nearly filled with granulated tin, and chlorine is passed in through the delivery-tube. It is best to have a little previously prepared tin tetrachloride in the bottom of the apparatus so that the delivery-tube dips under this liquid. Chlorine is now passed in at the ordinary temperature. Its disappearance is extraordinarily prompt, and the speed with which

the gas can be passed in is almost unlimited. As the amount of tetrachloride increases in the tube, it is necessary to raise the delivery-tube to avoid too great a pressure. The liquid is finally poured off and distilled, no purification on account of dissolved chlorine being necessary.—*Zeitschr. für Anorgan. Chem.*, ix, 365; x, 47. H. L. W.

5. *Argon and Helium.*—Bouchard has collected gases emanating from certain sulphur springs in the Pyrenees Mountains and has found that these consist chiefly of nitrogen, with both argon and helium. Troost and Ouvrard, working with the argon and helium just mentioned, claim that the spectrum lines of both these elements disappear when a magnesium wire is very strongly heated by electricity in contact with the gases in a Plücker tube. The authors assume that argon and helium are capable of combining with magnesium at very high temperatures, and they state that platinum gives in argon phenomena of volatilization and combination analogous to those presented by magnesium. These conclusions evidently conflict with previous observations upon these new elements.—*Compt. Rend.*, cxxi, 392 and 394. H. L. W.

6. *Photography of Colors by the indirect method.*—A. and K. Lumière take three negatives through orange, green, and violet ray filters. To obtain a positive they employ a film on glass which contains ammonium bichromate and bromide of silver. The negative is printed upon this, and the subsequent washing develops a transparent, hardly percepible image, which only through color is strengthened to the requisite depth. This first image is flowed with collodion, which is sensitized in the same manner as the glass, and is exposed to the second negative, and, in the same manner, to the third. Repeated layers can be used to strengthen the one or the other color until the required effect is obtained.—*Comptes Rendus*, cxx, pp. 875–876, 1895. J. T.

7. *Spectrum of Carbon of the electric oven.*—Moissan has shown that the carbon in an electric oven through which powerful electric currents have flowed is free from foreign admixtures. Deslandres has confirmed this and finds only a trace of calcium present. The self-purification comes from a species of distillation of the volatile impurities. The purest carbon is found at the negative pole. The following spectrum is obtained between $\lambda = 480$ and $\lambda = 220$.

Intensity.	λ.	Intensity.	λ.
8	426·70	8	283·64
5	392·17	4	274·75
4	391·97	8	264·12
2	316·83 } ?	8	251·15
1	316·57 }	8	250·79
2	299·34	10	247·88
1	296·77	8	229·70
8	283·75		

—*Comptes Rendus*, cxx, pp. 1259–1260, 1895. J. T.

8. *Measurement of high Temperatures.*—In a second paper L. HOLBORN and W. WIEN discuss the use of the increased resistance of platinum, and the use of a thermal junction of platinum and platinum-rhodium (10 per cent rhodium). They enter into a discussion of the constancy of the indications of the thermal junction. The determination of a number of boiling points of different metals by different methods was undertaken, and it was shown that the thermo element gave very constant indications, if it is protected from the action of carbon; and that the formation of platinum silicate at high temperatures in the protecting cylinders of porcelain or clay do not influence it to a marked degree. It was found with the method of the resistance of platinum, that the temperature-coefficient of the resistance was much more sensitive toward outside influences than the thermo element and that many precautions had to be taken to measure this coefficient. The formation of platinum silicate lowers not only the temperature-coefficient but also increases the resistance of the platinum. By means of an oven of clay of peculiar construction a temperature of 1570° was reached. The following table of melting points gives their results in comparison with other observers:

	Violle.	Barus.	Barus.	Holborn and Wien.
Silver	954°	986°	985°	971°
Gold	1045	1091	1093	1072
Copper	1054	1096	1097	1082
Nickel.....	....	1476	1517	1484
Palladium	1500	1585	1643	1587
Platinum	1775	1757	1855	1780

Violle used a calorimetric method and interpolated the specific heat of platinum from 1200° upward.

Barus used a thermo element of platinum iridium and placed the element not in the interior of the air chamber but outside. His measures extend to 1050°. The higher melting points are extrapolated. Holborn and Wien claim that very different temperatures are obtained in the inside and outside of the chamber. In order to obtain a better equilibrium of temperature, Barus causes the muffel of the oven to rotate. The constancy of the thermo element used by the authors of this paper was tested by the comparison of many determinations of melting points. With different thermo elements the determination at 1000° did not vary more than $\pm 5°$. The thermal function does not vary from year to year or from use or disuse.

Keiser and Schmidt of Berlin make, under direction of the authors, a D'Arsonval galvanometer of which the pointer moves over two scales, on one of which can be read the difference of potentials in volts; on the other the degrees of temperature indicated by the thermo element. The paper concludes with a statement of the superiority under different conditions of the method of the thermo element over the method of the resistance of

platinum.—*Ann. der Physik und Chemie*, No. 10, 1895, pp. 360–396. J. T.

9. *Absorption of Kathode rays.*—The phenomenon of kathode rays is receiving much attention from various observers in Germany and England. The current number of the "Annalen der Physik und Chemie" contains two papers on this subject. P. LENARD investigates the permeability, so to speak, of many gaseous and also solid media to the kathode rays and endeavors to frame a law which will express a relation between the absorption power and the thickness of the layers. O. LEHMANN criticises the results of Plücker, Hittorf, Goldstein, Crookes, Hertz, E Wiedeman and H. Ebert.—*Ann. der Physik und Chemie*, No. 10, 1895, pp. 255–275 and pp. 304–346. J. T.

II. GEOLOGY AND MINERALOGY.

1. *On underground temperatures at great depths;* by ALEXANDER AGASSIZ (from a letter to the editors, dated Calumet, Mich., Nov. 14, 1895.)—For several years past I have with the assistance of our engineer, Mr. Preston C. F. West, been making rock temperature observations as we increased the depth at which the mining operations of the Calumet and Hecla Mining Co. were carried on. We have now attained at our deepest point a vertical depth of 4712 feet, and have taken temperatures of the rock at 105 feet, at the depth of the level of Lake Superior, 655 feet, at that of the level of the sea, 1257 feet, at that of the deepest part of Lake Superior, 1663 feet, and at four additional stations each respectively 550, 550, 561 and 1256 feet below the preceding one, the deepest point at which temperatures have been taken being 4580 feet. We propose, when we have reached our final depth, 4900 feet, to take an additional rock temperature and to then publish in full the details of our observations.

In the mean time it may be interesting to give the results as they stand. The highest rock temperature obtained at the depth of 4580 feet was only 79° F., the rock temperature at the depth of 105 feet was 59° F. Taking that as the depth unaffected by local temperature variations, we have a column of 4475 feet of rock with a difference of temperature of 20° F. or an average increase of 1° F. for 223·7 feet. This is very different from any recorded observations; Lord Kelvin, if I am not mistaken, giving as the increase for 1° F., fifty-one (51) feet, while the observations based on the temperature observations of the St. Gothard Tunnel gave for an increase of 1° F., sixty (60) feet. The calculations based upon the latter observations gave an approximate thickness of the crust of the earth, in one case of about 20 miles, the other of 26. Taking our observations, the crust would be over 80 miles and the thickness of the crust at the critical temperature of water would be over 31 miles, instead of about 7 and 8·5 miles as by the other and older ratios. With the ratio observed here, the temperature at a depth of 19 miles would only be about 470°, a very different temperature from that obtained by the older ratios of over 2000° F.

The holes in which we placed slow registering Negretti and Zambra thermometers were drilled, slightly inclined upward, to a depth of ten feet from the face of the rock and plugged with wood and clay. In these holes the thermometers were left from one to three months. The average annual temperature of the air is 48° F., the temperature of the air in the bottom of the shaft was 72° F. A. A.

2. *Geological Atlas of the United States.*—The first number of this great work of the United States Geological Survey has been completed and issued in twelve separate folios. Each folio contains, on sheets of heavy paper, 18½ by 21½ inches in size, two or more pages of description, four maps, and sometimes a fifth, illustrating the topography, the areal geology, the economic geology and the structural geology of the particular area surveyed; a fifth map-sheet, containing column sections, is added in several of the folios. On the inside of the stiff manilla covers is printed explanations of the topographic map, the geologic map and their uses. The scale of the maps in this atlas is mainly of the medium size adopted, viz. $\frac{1}{125,000}$; the sheets of the Livingston folio are of the smaller scale, $\frac{1}{250,000}$, and those of Anthracite-Crested Butte folio are of the $\frac{1}{62,500}$ scale. The Cripple Creek special map (in folio 7) is on the still larger scale of $\frac{1}{25,000}$. Contour intervals of 200 feet are expressed on the maps of the smaller scale, of 100 feet in the medium and larger scale, and of 50 feet in the special Cripple Creek map.

The geological features of the regions are expressed on the maps by colors and various patterns of dots and circles, and tints, overprinted or underprinted, and letter symbols, the meaning and use of which are clearly defined in the general explanation on the covers and in the special legend of each map. The maps are models of artistic beauty and perfection, and were engraved and printed by the U. S. Geological Survey, Bailey Willis editor, and S. J. Kübel chief engraver.

In the first number of the Atlas are the following twelve folios:

1. Livingston folio, Montana, by Iddings and Weed geologists, Arnold Hague in charge.
2. Ringold folio, Georgia-Tennessee, by C. W. Hayes.
3. Placerville folio, Cal., by Lindgren and Turner, Becker in charge.
4. Kingston folio, Tenn., by C. W. Hayes.
5. Sacramento, Cal., by Lindgren, Becker in charge.
6. Chattanooga, Tenn., by C. W. Hayes.
7. Pike's Peak, Col., by Whitman Cross.
   With a special sheet, the Cripple Creek special map also by Mr. Cross.
8. Sewanee, Tenn., by C. W. Hayes.
9. Anthracite-Crested Butte, Col., by Cross and Eldridge, Emmons in charge.
10. Harpers Ferry, Va., Md., W. Va., by Arthur Keith.
11. Jackson, Cal., by H. W. Turner, Becker in charge.

12. Esteville, Ky., Va., Tenn., by M. R. Campbell, B. Willis in charge

The following folios are also ready for distribution :

13. Fredericksburg, Md., Va.
14. Staunton, Va., W. Va.
15. Lassen Peak, Cal.
16. Knoxville, Tenn., N. C.
17. Marysville, Cal.
18. Stuartsville, Cal.
19. Stevenson, Ala., Ga., Tenn.
20. Cleveland, Tenn.

They are prepared by the U. S. Geological Survey and may be had for the price of twenty-five cents each from the Director of the Survey. The sheets of the Atlas began to appear in 1873.

H. S. W.

3. *Economic and Geologic Map of New York State.*— Mr. F. J. H. MERRILL, the Director of the New York State Museum, has prepared a small map, on a scale of about 14 miles to the inch, in which are indicated by colors and symbols the geological formation and the localities of economic minerals of the state. The geological features are based upon the map of 1844, with additions and corrections derived from maps and papers more recently published, and the unpublished material furnished by H. P. Cushing, W. B. Dwight, H. L. Fairchild, P. F. Schneider, F. J. H. Merrill, C. S. Prosser, Heinrich Ries and C. H. Smyth, Jr. The chief modifications of the geology from the older maps are seen in the areas of Cambrian and Pre-Cambrian, and of Devonian. In regard to the former the recent clearing up of the "Taconic controversy" has resulted in a more accurate delineation of the areas along the eastern border of the state. The results of recent studies in classification and areal distribution of the Devonian formations, is seen in the more accurate delineation of the areas of its three chief formations; the Upper Helderberg, Hamilton and Chemung. We notice that no attempt is made to distinguish the Olean from the underlying Upper Devonian formations, and a single color is used for all the formations from the top of the Hamilton upward to the Carboniferous. The upper limit of the Hamilton is evidently traced through the central part of the state by the Tully limestone, and as this is wanting in the western and eastern parts of the state, the limit is apparently placed at the point in the succession where the first representatives of neo-Devonian faunas begin, rather than where the meso-Devonian species cease. This draws the line at the one point in the series where the faunal change is evident in such sections as lack the lithological change from shales to limestone. If geologists, studying this part of the series, will bear in mind that the Tully limestone faunally belongs with the upper (Chemung) rather than with the lower (Hamilton) faunas, they will not be confused in determining their horizon in Chenango County and the counties eastward, where the Tully limestone

phase is wanting, and some of the lower species occur above the base of the Chemung formation. H. S. W.

4. *Lakes of North America;* by ISRAEL C. RUSSELL, pp. 1–125, figs. 1–9, Plates 1–23, Boston, 1895 (Ginn & Co.).—This little book, which its author modestly calls "a reading lesson for students of geography and geology," is more than a geological treatise on the nature and significance of lakes in the surface topography of the country. While it lacks nothing of scientific precision, and the orderly arrangement of the subject-matter is all that a specialist could wish, there is, also, something of that indescribable literary flavor found in Humboldt's "Ansichten der Natur" which indicates not only a thorough knowledge and appreciation of the details of the topography, but an esthetic sense of what constitutes the beautiful in a landscape.

As an illustration, in the midst of a description of the location and dimensions of Lake Tahoe, the author observes: "On looking down on Lake Tahoe from the surrounding pine-covered heights, one beholds a vast plain of the most wonderful blue that can be imagined. Near shore, where the bottom is of white sand, the waters have an emerald tint, but are so clear that objects far beneath the surface may be readily distinguished. Farther lakeward, the tints change by insensible gradation until the water is a deep blue, unrivaled even by the color of the ocean in its deepest and most remote parts. On calm summer days, the sky with its drifting cloud banks and the rugged mountains with their bare and usually snow-covered summits, are mirrored in the placid waters with such wonderful distinctness and such accuracy of detail that one is at a loss to tell where the real ends and the duplicate begins, etc." This is immediately followed by a scientific definition of the transparency as rendering a white disc 9·5 inches in diameter visible at a depth of 108 feet, the light traversing twice that distance through the water to reach the eye. The various chapters discuss in a brief but satisfactory manner the origin of lake basins, the movements of lake waters and their geological functions, the topography of shores, and the relation of lakes to climate and to time. The facts are largely derived from the author's own observations, which have been more elaborately described in the various publications of the United States Geological Surveys. He has also drawn from the observations of other workers in this field, as Gilbert, Davis, Dawson, Dutton, King, LeConte, Upham, Warren and others. A supplementary note on the classification of lakes by Wm. M. Davis closes this very readable book. H. S. W.

5. *Phonolitic Rocks from Montana;* by WALTER HARVEY WEED. (Communicated.)—The writer has recently returned from a reconnaissance trip through the Bear Paw mountains, Montana, where the two phonolitic rocks described in the November number of this Journal (vol. l, p. 394, 1895) were found in place. The mountains present a fine example of a group of dissected volcanoes. A large part of the area is covered by extrusive basaltic

rocks, scorias, breccias, and lava flows, while in the central portion of the range massive igneous rocks are well exposed as stocks, breaking up through but slightly disturbed Cretaceous strata. The basalts are probably leucitic and closely resemble those of the Highwood mountains. The rocks described occur as dikes cutting metamorphosed Cretaceous beds, and are found in the central portion of the mountains.

A further account of the geology and of the unusual rock types of this mountain group will be published jointly with Professor Pirsson at a future date.

6. *Crystallography: A Treatise on the Morphology of Crystals;* by N. Story-Maskelyne, M.A., F.R.S., Professor of Mineralogy, Oxford. 521 pp., Oxford, 1895 (The Clarendon Press).—More than fifty years have passed since Professor W. H. Miller published his classical work on Crystallography, which he based in part upon methods already known, but at the same time developed from them in a manner wholly his own, a system which has ever since borne his name. Early adopted by a limited school of Austrian crystallographers, it has gradually won for itself recognition, until now there are few workers who have not given proof of their conviction as to its superiority by adopting it. During this time many important works on Miller's System have been published both in German and French, but until now no notable contribution to it has been made in his own language. The present work of Professor Story-Maskelyne goes far to reconcile us for this long gap since in thoroughness and fullness of treatment it leaves nothing to be desired. The public may congratulate itself that the gifted author has felt finally ready to give to it the manuscript that he has had so long in preparation. The volume is limited to the Morphology of Crystals, discussing in detail the relations between the planes of a system, the properties of zones, the kinds of symmetry, the six crystalline systems and the methods of measurement and calculation of crystals. The whole is developed with admirable clearness and system, and will be studied carefully by all interested in this branch of science. The author promises a companion volume, dealing with the physical side of crystallography, and it is to be hoped that this may not be long delayed.

III. Botany.

1. *Missouri Botanical Garden. Sixth Annual Report.* St. Louis, 1895.—From the present report will be missed, but by no means as a real want, the full account of the proceedings at the two annual banquets instituted by Mr. Shaw, and the annual "Flower Sermon," which has not been, as a rule, particularly edifying. The trustees have been wise in dropping these matters and bringing out into their deserved prominence the excellent botanical contributions by the Director and others. Professor Trelease gives an admirable monograph on the interesting mono-

typic Leitneria, hitherto known with certainty only in Florida, but now discovered in the lowlands of southeastern Missouri. Mr. Jared G. Smith contributes a revision of the North American species of Sagittaria and Lophotocarpus, describing rather more than twenty of the former. He also, in a separate paper, notes a few facts relative to some new or little known species. Mr. Herbert J. Webber publishes some striking observations regarding the dissemination of certain species of Yucca, and comments on its relation to leaf-reflexion. Mr. B. F. Bush contributes interesting notes in regard to the plants which occur on the mounds in Atchison county, Missouri. The illustrations by Miss Johnson are, like those from her pencil in previous reports, remarkably spirited as well as accurate. G. L. G.

2. *Index Kewensis.*—An enumeration of the genera and species of flowering plants from the time of Linnaeus to the year 1885 inclusive, together with their authors' names, the works in which they were first published, their native countries and their synonyms; compiled at the expense of the late Robert Charles Darwin, under the direction of Joseph D. Hooker, by B. Daydon Jackson. Part IV, Oxford, Clarendon Press. 1895.

This part finishes the treatise which botanists in all departments owe to the generosity of Mr. Darwin. Sir Joseph Hooker gives in the preface the following interesting account of the inception of the work:

"Shortly before his death, Mr. Darwin informed me of his intention to devote a considerable sum in aid of the furtherance of some work of utility to biological science; and to provide for its completion should this not be accomplished during his lifetime. He further informed me that the difficulties he had experienced in accurately designating the many plants which he had studied and ascertaining their native countries had suggested to him the compilation of an index to the names and authorities of all known flowering plants and their countries as a work of supreme importance to students of systematic and geographical botany, and to horticulturists, and as a fitting mode of fulfilling his intentions.

"I have only to add that at his request I undertook to direct and supervise such a work, and that it is being carried out at the Herbarium of the Royal Gardens, Kew, with the aid of the staff of the establishment."

Even taking into account the errors both of date and name which unavoidably creep into a nomenclator planned on a scale so broad as to comprehend the generic and specific appellations bestowed during almost a century and a half, this work has fully carried out the liberal intentions of its patron. It is, as he predicted, indeed of supreme importance to the students of botany in every field. It is, moreover, a lasting monument to the sagacity of Sir Joseph Hooker, who framed the page with full regard to convenience and rapidity of reference, and, lastly, it gives evidence, throughout, of conscientious work on the part of Mr. Jackson and his associates. G. L. G.

IV. Miscellaneous Scientific Intelligence.

1. *Le Pétrole, L'Asphalte et le Bitume au point de vue géologique* par A. Jaccard. 292 pp. Paris, 1895 (Félix Alcan)—Bibliotheque scientifique, lxxxi.—The subject to which this volume is devoted is one of high scientific interest as well as great economic importance. The author, M. Aug. Jaccard, who died at Locle, Switzerland, on the 5th of January of the present year, had devoted much of his life to the study of this department of geology and his clear, systematic presentation will be found interesting and valuable. He gives a critical history of the various scientific theories in regard to the origin of petroleum, from the time of von Buch (1801); he also discusses its mode of formation and the important deposits. A later account is given of bitumen, asphaltum, natural gas, etc. The closing chapter contains some statistics in regard to the production of petroleum and suggestions in regard to its future. The author declares himself strongly in favor of the sedimentary and organic origin of the deposits of hydrocarbons as opposed to the eruptive and inorganic; he also repeatedly argues that it is unnecessary to invoke violent causes to explain the observed facts. Further he urges that many authors have confounded the original formation of bitumen with the subsequent phenomenon of its reappearance at the surface.

2. *Les Aurores polaires* par Alfred Angot. 318 pp. 8vo. Paris, 1895 (Félix Alcan)—Bibliothèque scientifique internationale publiée sous la direction de M. Ém. Alglave, lxxx.—An interesting and popular account is given of auroras in their many forms; numerous excellent illustrations show some of the most remarkable occurrences. The various theories advanced to account for auroras are detailed, and preference is given to that of Edlund, based on unipolar induction, as being most satisfactory (Swedish Acad., vol. xvi, 1878). An appendix, of 90 pages, gives a catalogue of auroras observed in Europe below lat. 55° from 1700 to 1890.

3. *Une Excursion en Corse*—Prince Roland Bonaparte. 273 pp. Paris, 1891.—This handsome volume is an interesting account of a visit by Prince Roland Bonaparte to Corsica in 1887. The scientific observations made, in physical geography, geology, anthropology, etc., were presented at a meeting held in Berne on December 18, 1889. The story of the trip, its incidents, the picturesque features of that charming region, are here presented in most readable form. Several beautiful views add charm to a very attractive volume. An extensive bibliography of works relating to Corsica fills the latter half of the work.

William Wesley & Son: The Natural History and Scientific Book Circular, No. 124: Astronomy, including works from the Libraries of Sir G. B. Airy, F.R.S., and A. C. Ranyard, F.R.A.S. 56 pp, including 1789 numbered works.

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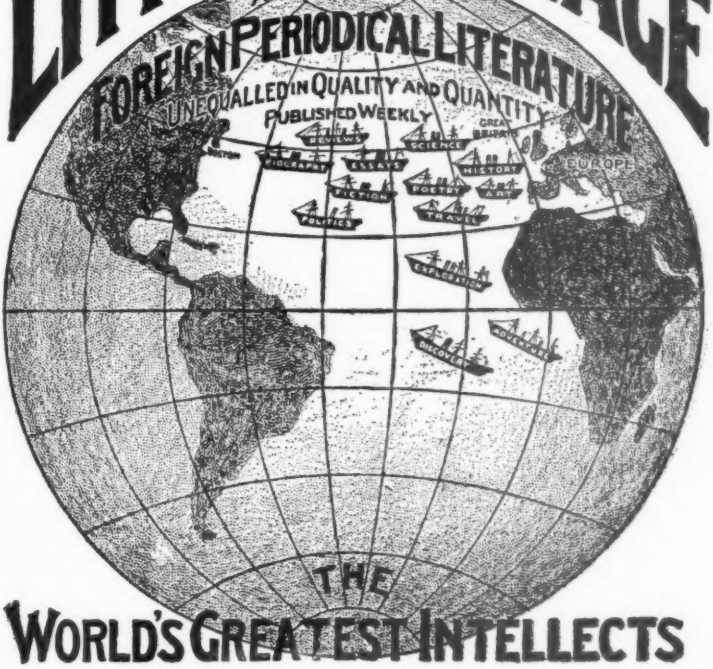

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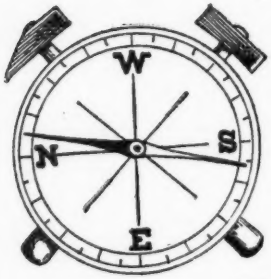

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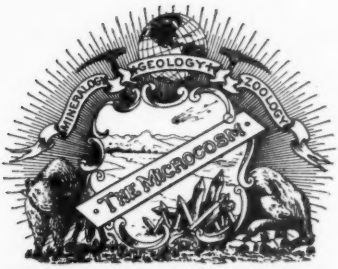

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